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Vol. XVII, No. 3

JANUARY, 1958

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Project Stratoscope

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COVER: The scene at dawn on September 25, 1957, at the General Mills Flight Center, New Brighton, Minnesota, during the launching of a Skyhook balloon carrying the solar camera of Project Stratoscope to an altitude above 80,000 feet. There pictures of the sun's photosphere were taken that are unsurpassed in showing details of the solar granulation. Near the balloon, several men are standing alongside the parachute for returning the apparatus safely to earth. On the back of the truck in the right of the picture is the equipment itself, the 12-inch reflector held in its stowed position, but later to be turned by automatic controls to point at the sun. U. S. Navy photograph, courtesy Princeton University Observatory. (See page 112.)

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Artificial Meteors

ON OCTOBER 16th, at 10:13 p.m. Mountain standard time, the first observable artificial meteors were produced by shaped charges that blasted aluminum pellets into the atmosphere at a height of 54 miles. Friction with the air caused the pellets to glow, several bright enough to be recorded by ground-based cameras at the Air Force Missile Development Center, Alamogordo, New Mexico.

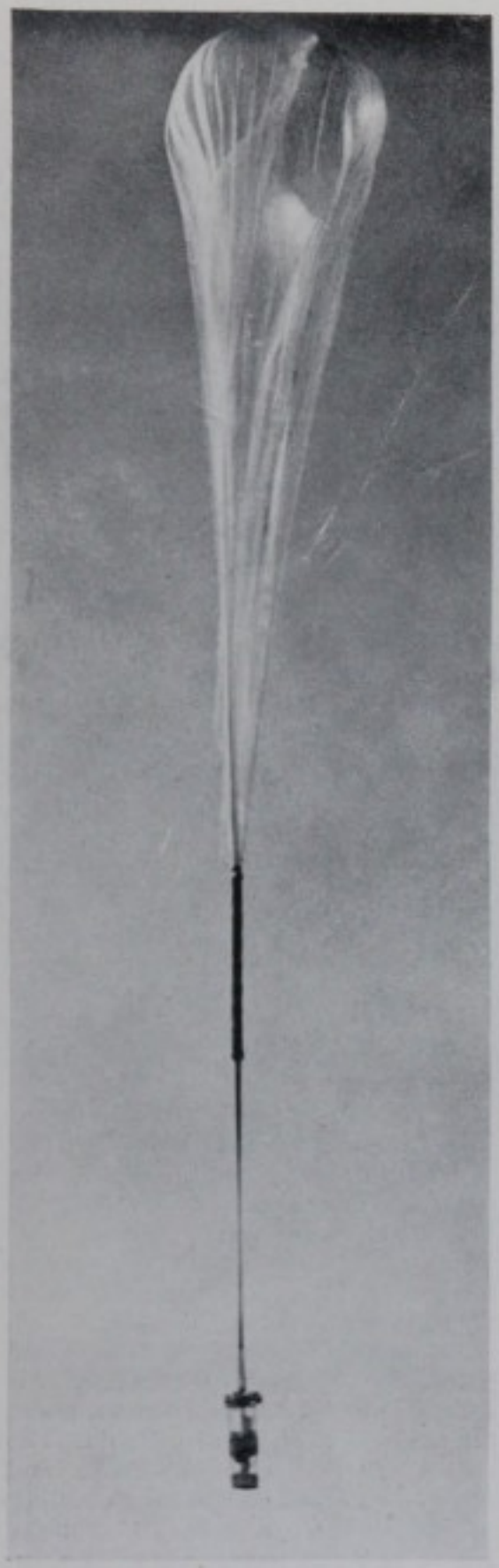
One excellent photograph was obtained with a Baker super-Schmidt meteor camera at the neighboring Sacramento Peak Observatory. It shows an artificial meteor traveling at a speed greater than 33,000 miles an hour, with a brightness of magnitude −2 (about as bright as Jupiter). Another picture taken by a missile-tracking camera on the rocket range at Holloman Air Force Base shows that at least two artificial meteors were produced.

The velocity of escape from the earth's gravity is about 25,000 miles an hour, so the shaped charges had given some of the pellets enough speed for them to have gone into interplanetary space, had their heights been great enough so that atmospheric friction could not have burned them up.

When the Aerobee missile used in the experiment reached an altitude of 85 miles, the rocket tip, containing three shaped charges, was automatically separated from it, to avoid later damage to other instrumentation in the rocket. At 54 miles the blast occurred, observed from the ground as of magnitude −10 (brighter than the quarter moon). It appeared more brilliant than any star or planet to watchers on Palomar Mountain, about 600 miles from the launching site.

The experiment was carried out by the Geophysics Research Directorate, Air Force Cambridge Research Center, under the supervision of Maurice Dubin. The shaped charges were fabricated and mounted by Fritz Zwicky, California Institute of Technology, and T. C. Poulder and M. C. Wells, Stanford Research Institute. Ten years ago, in 1947, Dr. Zwicky had first tried to produce artificial meteors by firing shaped charges from a V-2 rocket, and other attempts have been made since that time.

Until recent years, our knowledge of the density, temperature, and wind velocities at heights in the atmosphere between 25 and 70 miles was largely based on visual observations and photographs of fireballs and meteors. They may collide with the earth's air at speeds ranging between 27,000 and 160,000 miles an hour. Artificial meteors of known properties produced within these heights and ranges of speed should prove even more useful than natural meteors for studying the physics and chemistry of the atmosphere.



PROJECT STRATOSCOPE— Solar Photographs from 80,000 Feet

JOHN B. ROGERSON, JR., *Princeton University Observatory*

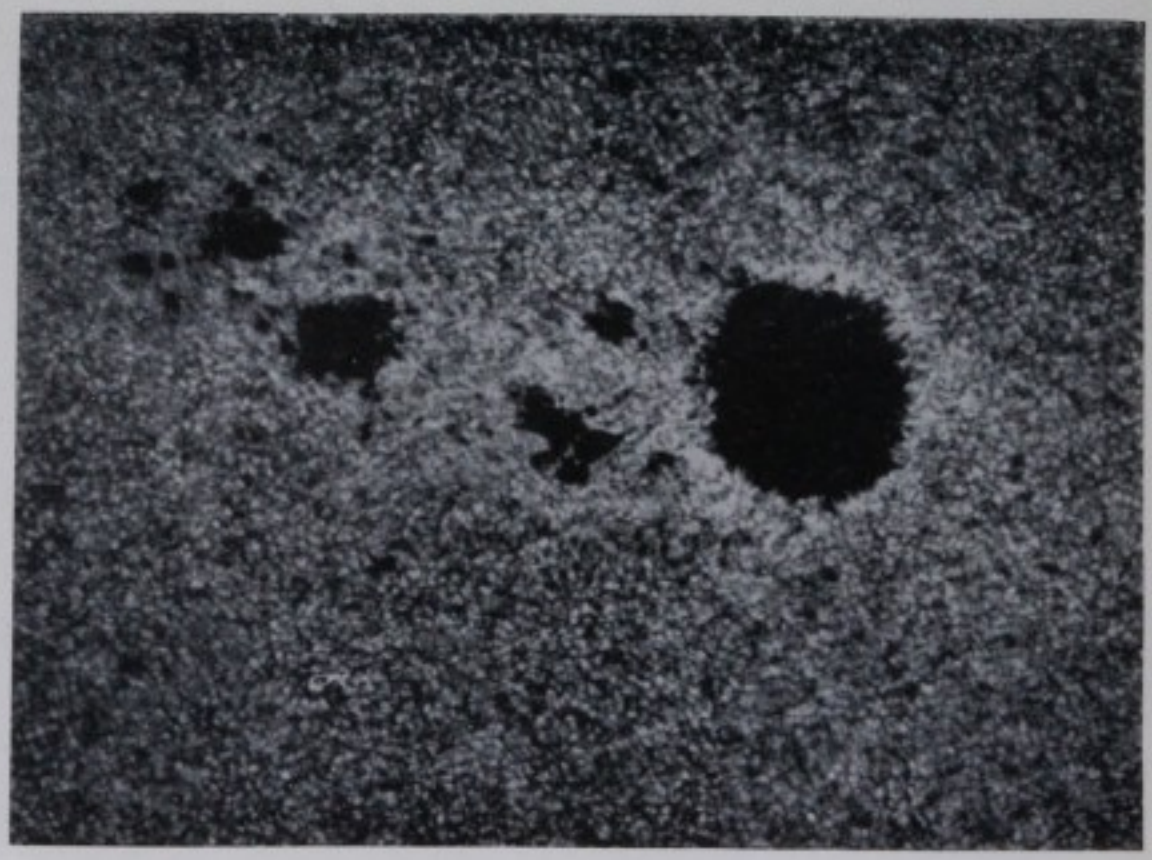
OUR PLANET'S ATMOSPHERE continually tantalizes the astronomical photographer. At best it is only semitransparent, and most of the time its motions blur his pictures. And in solar photography, where we are interested in recording small details on the sun's surface, poor seeing conditions are a most important limitation.

It is no wonder that astronomers have long wanted some stable observing platform placed well above the swirling murk of the lower atmosphere, so their telescopes could be used to full advantage. A major advance toward this goal was achieved on September 25, 1957, when a 12-inch reflecting telescope was carried aloft by an unmanned Skyhook balloon to a height of more than 80,000 feet over Minnesota, and solar photographs of unprecedented definition were secured.

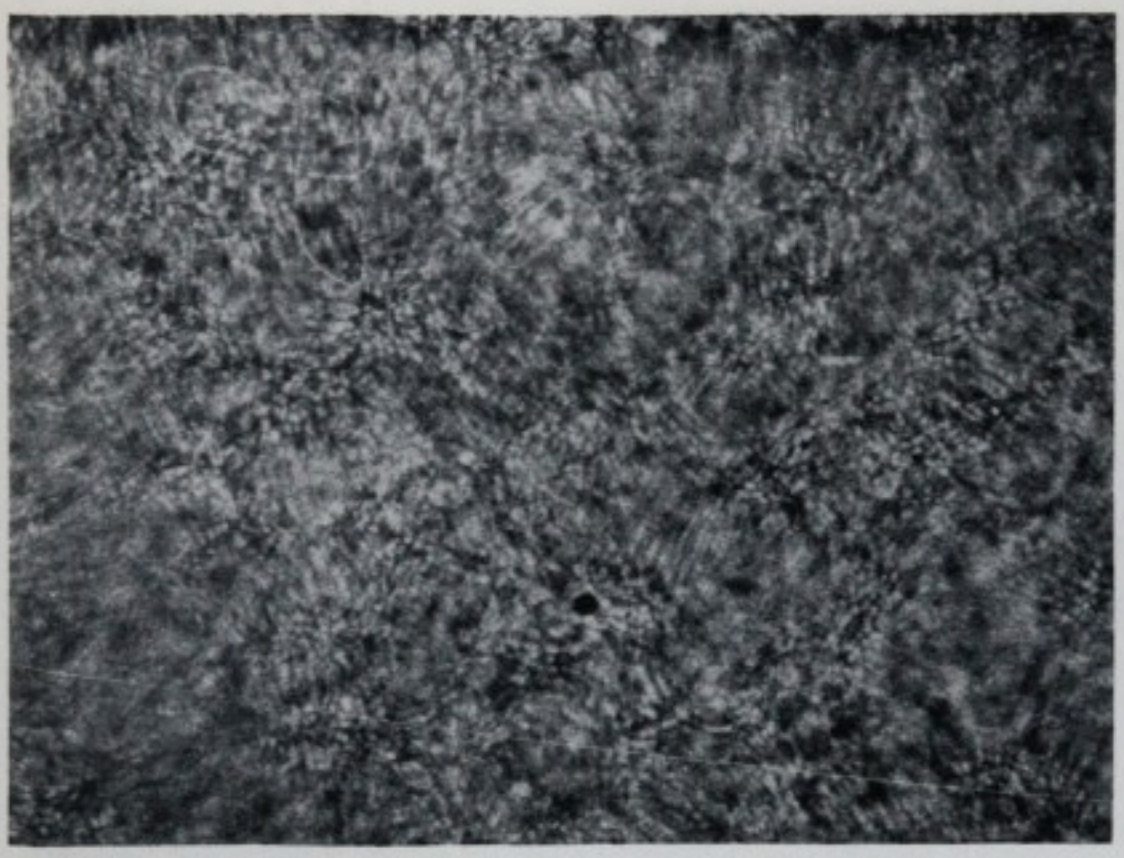
This flight was part of Project Stratoscope, on which the writer has been working under the leadership of Princeton astronomer Martin Schwarzschild, with the support of the Office of Naval Research and the Air Force Cambridge Research Center. Dr. Jack Evans, director of Sacramento Peak Observatory, has been pushing this work actively over a period of years, and has advised on many technical details. Dr. Lyman Spitzer, Jr., director of Princeton University Observatory, played a major role in the inception of the project and was frequently consulted on the many problems that arose.

For over a decade, Dr. Schwarzschild has been studying the problem of the solar granules, which are seen as tiny bright specks densely spread over the sun's surface in very great numbers. The granules are so minute that they are difficult to observe effectively. Individual grains are short-lived, forming and vanishing within a few minutes. They are thought to be rising currents of turbulent gas that

Above: On the 10th anniversary of the first Skyhook balloon flight, one of these giant polyethylene bags rises into the sky with the Stratoscope camera hanging beneath. The launching preparations are pictured on the front cover of this issue. U. S. Navy photo.



Right: Solar granulation appears brighter and more distinct in the neighborhood of a sunspot group, in this photograph obtained by Jules Janssen at Meudon Observatory on April 1, 1894. He used a 5.3-inch refractor on a simple wooden mounting, with an exposure of 1/3,000 second on a collodion wet plate. The diameter of the largest sunspot is about 22 seconds of arc, some 10,000 miles.



Another Janssen photograph of the sun's surface, taken June 10, 1887, shows the effects of uneven seeing in the earth's atmosphere. The granulation is sharp only in small areas, separated by blurred regions. Janssen's pictures are reproduced from Vol. 1 of the "Annales" of Meudon Observatory (1896). The scale of this picture is about 2.15 seconds of arc per millimeter.

play an important part in the transport of energy from the hot solar interior outward into space.

More than 60 years ago, excellent photographs of solar granulation were obtained by J. Janssen at the Meudon Observatory in France. Until recently, they have hardly been equaled. Two of his pictures, reproduced here, illustrate the high quality of his results and also the effects of atmospheric turbulence on photographs of the sun's surface. On the basis of pictures like these the granules were long supposed to be some 500 to 1,000 miles in diameter.

Janssen himself mentioned that typical granule diameters lie between one and two seconds of arc, corresponding to linear dimensions of 450 to 900 miles. With his 5.3-inch refractor, it was possible for him to see this size of granule. He could not, however, resolve the smallest granules he claimed to have seen, namely $\frac{1}{3}$ and $\frac{1}{4}$ second of arc.

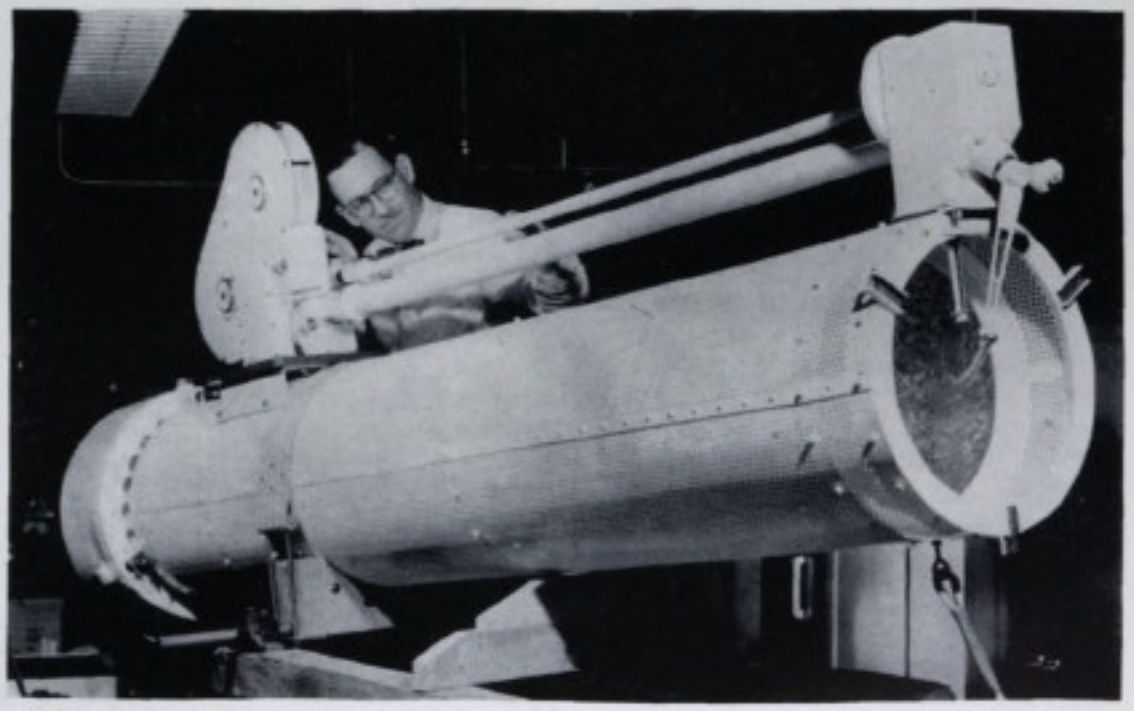
In May, 1949, with the 150-foot tower telescope at Mount Wilson Observatory, R. S. Richardson succeeded in taking a high-dispersion solar spectrogram of unusual excellence. The spectral lines were not perfectly straight, but slightly wavy because of Doppler shifts due to motions of the granules. From measurements of these shifts, Drs. Richardson and Schwarzschild inferred the possible existence of turbulent elements in the sun's photosphere on the order of only 150 miles in diameter, with velocities of roughly two kilometers per second.

Granules of this size would be too small to be photographed by ordinary techniques. Project Stratoscope was planned specifically to solve this observational problem, by carrying a large telescope well above the densest part of the atmosphere. Already in November, 1956, and later, in April, 1957, photographs of the solar granulation had been taken at altitudes of 20,000 and 25,000 feet from a manned balloon. This work was carried out by D. E. Blackwell and D. W. Dewhirst, Cambridge University Observatory, in collaboration with A. Dollfus, Meudon Observatory. Using an 11-inch refractor, they obtained definition as good as the best ground-based photographs to date.

The current project consisted of three balloon ascents from the General Mills Flight Center, New Brighton, Minnesota. The first of these, on August 22, 1957, carried a dummy telescope, plus a special instrument to test the quality of the guiding provided by the pointing mechanism. The latter had been constructed by the Research Service Laboratories of the University of Colorado. This flight reached an altitude of 82,500 feet.

The second flight was launched at 6:15 a.m. Central standard time on September 25th. At some 40,000 feet the giant Skyhook balloon passed through the tropopause, the atmospheric layer in which many astronomers believe much bad seeing originates. While the balloon hovered at a predetermined altitude of about 82,500 feet for $4\frac{3}{4}$ hours, the photoelectric tracking device kept the camera pointed toward the center of the sun. At intervals of one second, 35-mm. photographs were taken continuously until some 8,000 frames had been secured. Then the telescope, with its accessory instruments and exposed film, was automatically separated from the balloon and parachuted to earth, landing near Athens, Wisconsin, at 1:14 p.m.

A third successful flight was carried out on October 17th. The 12-inch telescope, which with its accessory equipment weighed 1,400 pounds, was lifted to a maximum height of over 84,000 feet. For this flight, the pointing control was modified in such a way as to cause the telescope to scan slowly back and forth across the limb of the sun. Five such scans were made during the nearly $2\frac{1}{2}$ hours of camera operation. As with the first two flights, the instruments were recovered very nearly intact. The repairs of the landing



The 12-inch Stratoscope reflector set up for testing in the shop. The enlarging-lens system that scans over the maximum focal range every 20 seconds is seen extending downward from the top side of the tube, just above the rotating secondary mirror. A specially designed 35-mm. movie camera is mounted near the left end of the telescope, light reaching it through the larger of the two tubes. Perkin-Elmer photograph.

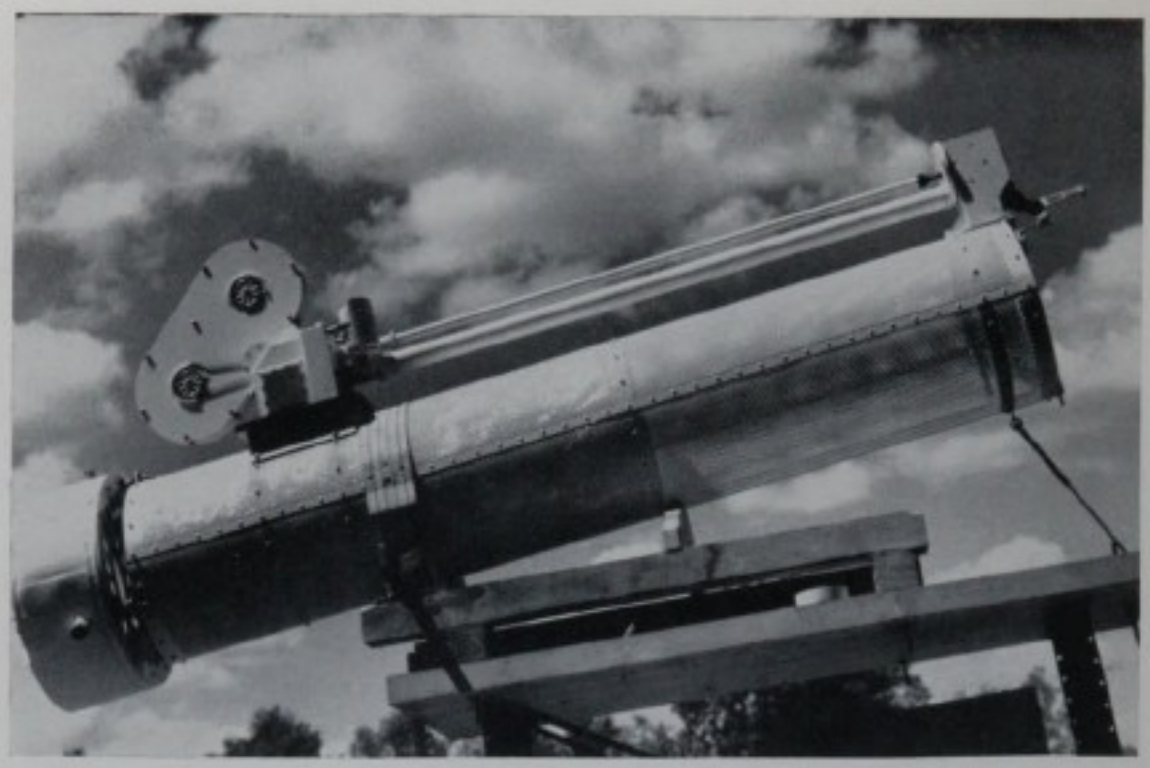
damage averaged about five per cent of the construction costs for each flight.

The special reflecting telescope was designed by George A. Brueske and built under the direction of William M. Strouse at the Perkin-Elmer Corp. The instrument has a 12-inch f/8 paraboloidal mirror, with an enlarging lens system which produces an effective focal length of 200 feet. Only a small portion of the nearly two-foot image of the sun can be photographed on one frame of the 35-mm. movie camera. The telescope itself is 9½ feet long, and weighs about 300 pounds.

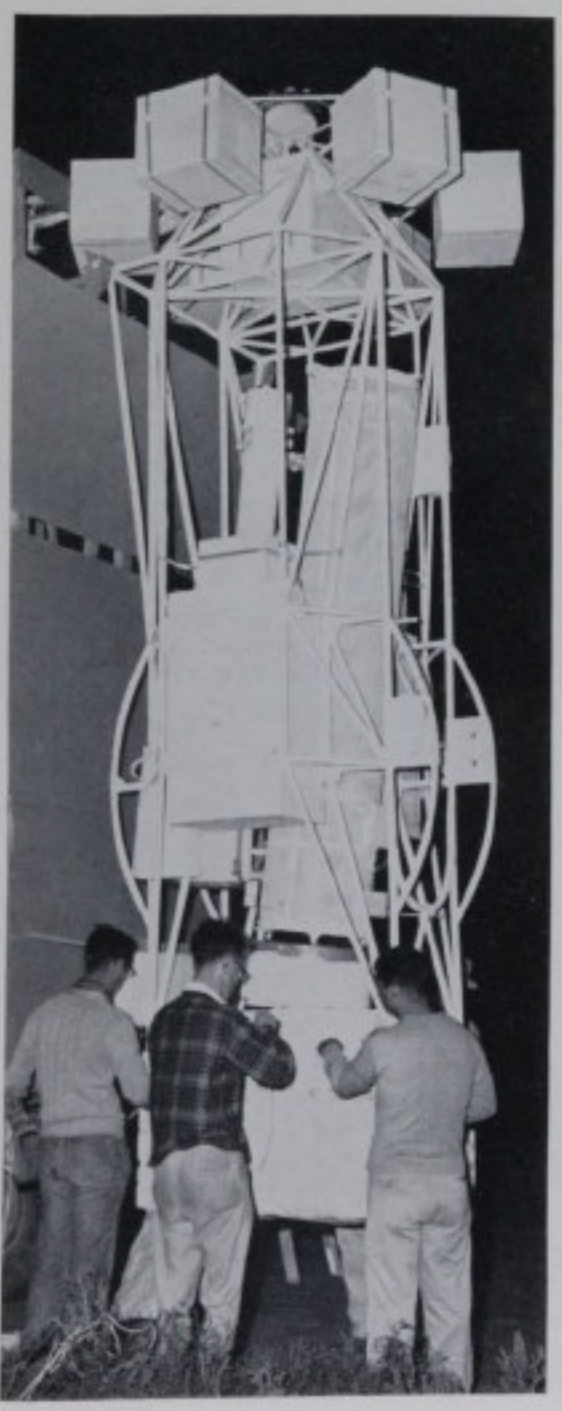
Solar heating and temperature variations at such great altitudes influenced the design and operation of the telescope. Its walls were made of perforated Invar steel to minimize thermal expansion and contraction. The aluminized quartz secondary mirror was arranged to rotate so that it would face the heat of the sun only two per cent of the time, reflecting the image into the enlarging system only at the times of picture taking.

As no sure way was known of predicting the exact changes in focal length under the extreme conditions of high altitudes, successive exposures were taken at different focal settings over a range of 10 to 20 times the focus tolerance. This was achieved by moving the enlarging lens back and forth about the estimated position of best focus. This estimate was reasonably accurate, so the actual focus did lie within the small range scanned. The motion of the enlarging lens was mechanically coupled to the rotational motion of the secondary mirror, so that 20 pictures were taken during each scan cycle.

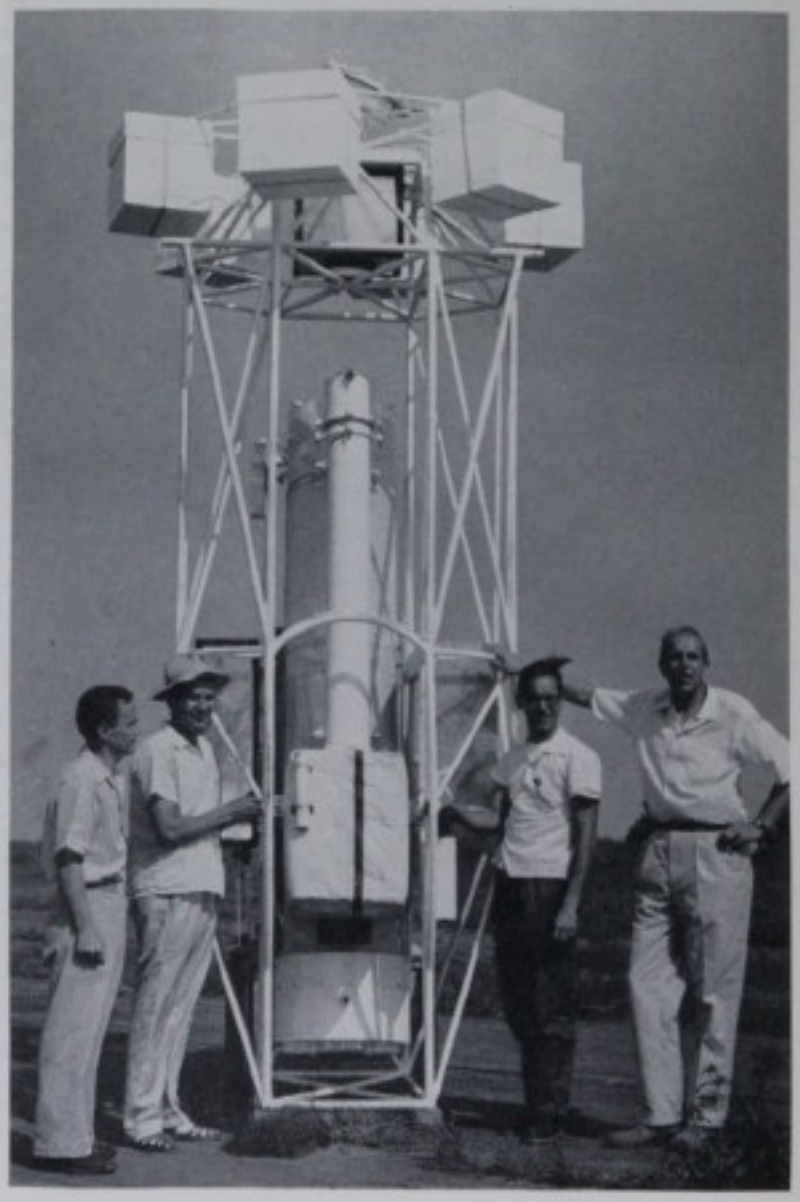
In pointing the telescope, pairs of photo-diodes were employed to find the sun and to center the instrument on it. These photo-diode "eyes" were arranged so that both eyes of a pair saw the same amount of sunlight when the telescope



The arrangement of parts in the solar telescope is easily seen in this picture, taken in July, 1957, at the Perkin-Elmer plant. The small, uppermost tube is a drive shaft from the camera motor to rotate the secondary mirror and shift the enlarging lens back and forth to scan the focus range.



Left: This night scene shows the equipment carried beneath the balloon. The men are attaching the polystyrene-foam crash pad that absorbs the shock when the instrumentation is dropped by parachute to the ground.



Right: Another view of the telescope and its suspension. At the top are the six battery cases. The heavy box contains the movie camera. In the group, left to right, are Dr. M. Schwarzschild, Princeton astronomer; R. A. Nidey and C. J. Roubique, University of Colorado, who were responsible for the pointing control; and E. E. Beson, General Mills project director for Stratoscope. U. S. Navy photographs.

was pointing directly at the sun in one co-ordinate. Thus, if the telescope were not pointing correctly, one eye would see more sunlight than the other, and this information would cause the servo-mechanism to move the telescope in such a way as to bring the illumination of the eyes into equality.

By using several pairs of eyes, the telescope was pointed both in azimuth and in elevation. Motion in azimuth was obtained by reacting against a heavy flywheel, the main mass of which was provided by the heavy storage batteries necessary as a power source. The telescope was moved in elevation against the pendulum action of the gimbal structure in which it was mounted.

In these ascents, unmanned flight had another important advantage besides increased payload; small motions, even breathing, by a human observer would cause intolerable amounts of telescope motion. Upper-air winds were not expected to swing the equipment through more than a fraction of a degree.

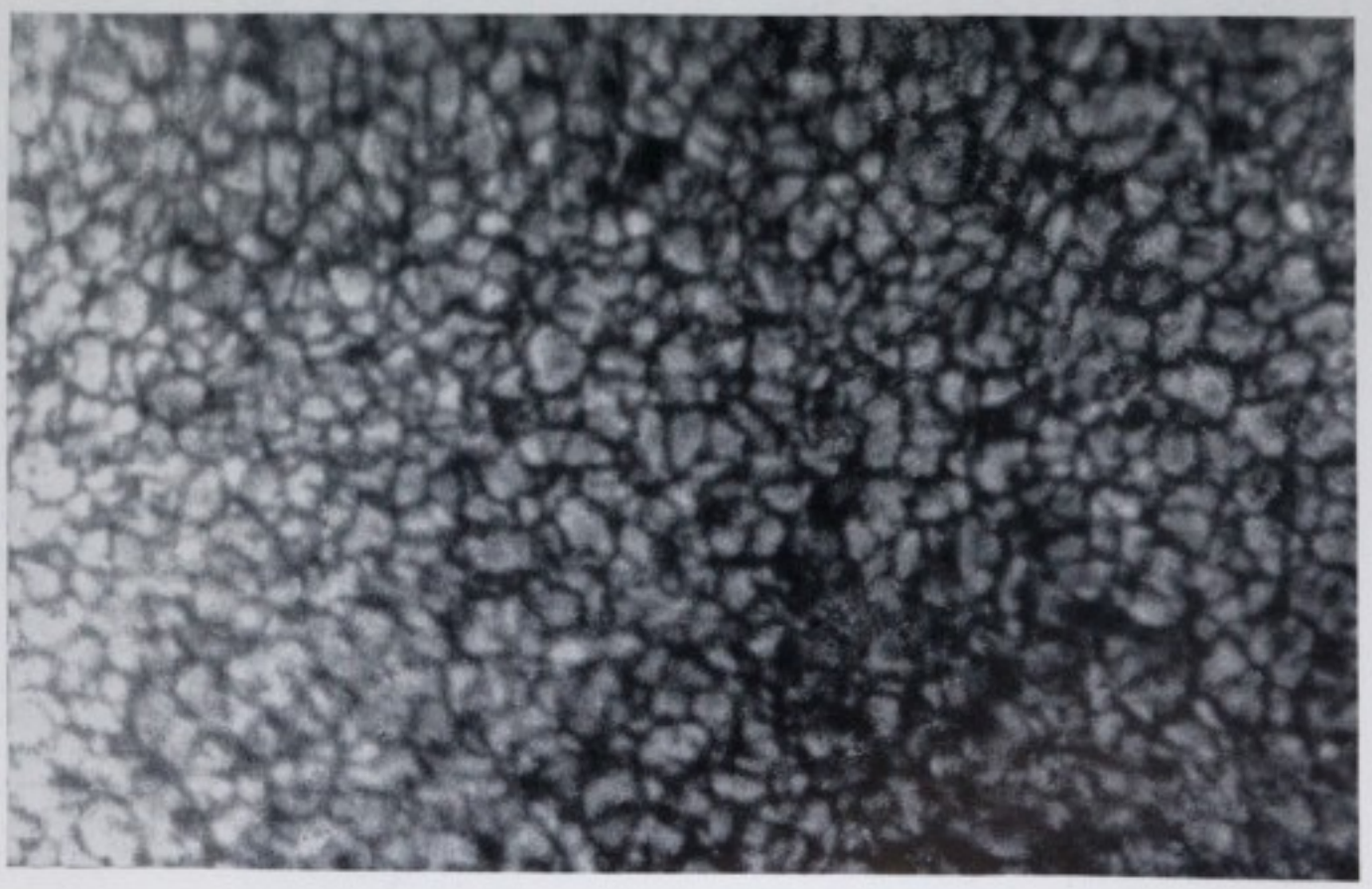
From the thousands of exposures made on these flights, several pictures of very high definition were obtained, with sharper resolution than ever achieved before. They include both the center of the solar disk and the limb, and show that the solar granulation has a cellular, though highly irregular, character. The bright cells appear to be separated from each other by dark, often very sharp lines. Thus, instead of hot rising currents and cool descending ones of about the same size, there appear to be only thin lines of descending gas separating the rising columns. The sizes of the granular elements range from two down to $\frac{1}{3}$ second of arc, or to as small as about 150 miles on the sun's surface.

The results of Project Stratoscope are so promising that plans are under way for further ascents in which the 12-inch telescope will be used with a television pickup tube. The image would be relayed to the earth's surface for reproduction on a television screen, giving the ground observer the possibility of selecting interesting regions of the solar surface or improving the focus by means of remote control.

A further step, which may be a number of years ahead, is to carry a 36-inch telescope aloft by balloon. The greater light-gathering power and higher resolution, coupled with the excellent seeing at 80,000 feet, should permit successful attacks on a number of important problems, including planetary surface features, fine details of the structure of nebulae, and resolution of nearby stellar systems.

This article was prepared with the assistance of the editorial staff of *Sky and Telescope*.

At the launching site in the Minnesota countryside, the equipment of Project Stratoscope is being tested prior to the second flight, which took place September 25, 1957. The assembled gear is hanging in a specially constructed tent with east and west side flaps that can be raised to permit testing of the pointing control. The author of this article is standing at the extreme right.



One of the high-quality photographs of the solar surface taken by the Stratoscope camera from above 80,000 feet. It shows granulation near the center of the sun's disk on a scale so great that one millimeter corresponds to 0.4 second of arc, or about 190 miles, in this retouched enlargement from the 35-mm. negative. Photographs like this one obtained by Project Stratoscope will require elaborate measurement and analysis before their full value is exploited.

The Veil nebula in Cygnus, photographed in red light (wave lengths 6400 to 6600 angstroms) by R. Minkowski, with the 48-inch Schmidt telescope on Palomar Mountain. This is a positive print, on a reduced scale, of the negative reproduction on the center pages of this issue. North is at the left of this view. The dense mass at the top is NGC 6960, in which is involved the 4th-magnitude star 52 Cygni. At the lower left is the bright "flaming" nebulosity NGC 6992, whose more open right-hand end bears the label NGC 6995. This entire expanding chaos of luminous gas has been interpreted by astronomers as the debris of a great stellar explosion. Mount Wilson and Palomar Observatories photograph.

The Veil Nebula as a Supernova Remnant

OTTO STRUVE, *Leuschner Observatory, University of California*

THE GREAT Loop nebula in Cygnus, commonly called the Veil or Network nebula, is one of the most interesting objects in the sky. It was discovered visually by William Herschel in 1784, with an 18.7-inch reflecting telescope. His description tells of two streamers of nebulosity, each some two degrees long, and about three degrees apart. A century later, photographs by Max Wolf and by E. E. Barnard showed these streamers to be parts of a huge ring.

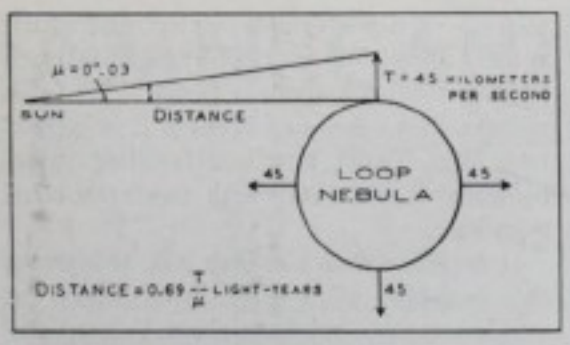
The intricate filamentary structure of the Veil nebula may be clearly seen in the picture above, which is a reduced copy of a large-scale negative in the center of this issue. This photograph was taken by R. Minkowski with the 48-inch Schmidt telescope on Palomar Mountain. He used a red-sensitive emulsion which records mostly the light of the red emission line of hydrogen (Hα).

A highly significant property of this Cygnus Loop is its expansion. In the annual report of the director of Mount Wilson Observatory for 1925-26, we read: "As a result of the comparison of two photographs, made 15 years apart, of the Net Work Nebula in Cygnus, in which [NGC 6960 and 6992] form opposite segments of the great loop, Hubble finds an expansion of the diameter of the nebula at the rate of about 10″ a century." Later, according to the annual report for 1936-37, Hubble revised this value to 0.06 second of arc per year, from measurements of photographs 27 years apart. Apparently the details of Hubble's work have never been published, and we do not know just which features of the nebulae he measured.

The only detailed investigation of the proper motions of NGC 6960 and 6992 known to me was published in 1954 by the Russian astronomers V. G. Fessenkov, B. M. Kazachevsky, and L. N. Toulenkova in the *Astronomical Journal of the Soviet Union*. They too found that the loop is growing, at about the rate Hubble believed. However, the drifts of individual points in the nebula show great scatter: in addition to the systematic expansion, there are also indications of random turbulent motions.

The diameter of the brightest part of the loop is some 2.7 degrees, or about 9,700 seconds of arc. If the loop has been growing at a constant rate, its age would be 9,700/0.06 or about 160,000 years. But, as F. Zwicky pointed out in 1940, it is by no means certain that the nebula has been expanding at a steady rate. How much the velocity of expansion has decreased and what may be the real age of the nebula require further study.

First of all, we need to know its dis-



This diagram indicates how the distance of the Loop nebula can be computed, if both the angular and linear speeds of expansion are known from observation.

tance. There is no hope of determining the trigonometric parallax directly, for the nebular filaments are not sharp enough to be measured with the accuracy needed. But M. L. Humason has measured on low-dispersion spectrograms the radial velocities of certain nebulous wisps. His unpublished results indicate that the nearest portions of the loop are approaching us at roughly 45 kilometers per second. (The usually quoted value of 75 kilometers per second is, according to Minkowski, the maximum possible value.)

Suppose, then, that the radius of the nebula is growing symmetrically at a rate of 45 kilometers per second. We can calculate how far away the loop must be for the diameter to be increasing by 0.06 second per year. The result is about 1,000 light-years. Minkowski, too, has suggested that the Loop nebula may be this distant, but not 1,500 light-years away, as has often been assumed.

Next, we need to know the linear diameter of the nebula. If the distance is 1,000 light-years, the diameter turns out to be roughly 50 light-years. This is nearly 5×10^{19} centimeters, so the entire volume would be about 6×10^{58} cubic centimeters. We know very little about the density of the nebula, but we can assume that the average density throughout the loop may be roughly the same as for interstellar gas — one hydrogen atom per cubic centimeter. Since a hydrogen atom has a mass of 1.7×10^{-24} grams, this would give $6 \times 10^{58} \times 1.7 \times 10^{-24}$, or about 10^{35} grams for the mass of the entire sphere.

This may well be an overestimate for the amount of gas ejected in the hypothetical explosion that gave rise to the nebula. During the expansion this gas has become mixed with the interstellar gas. Perhaps only one-tenth, or 10^{34} grams, was initially released. Even this is five times as great as the mass of the sun (2×10^{33} grams). And under any reasonable assumptions, we cannot attribute to the original shell a mass much less than the sun's.

If, as seems almost certain from the expansion, the Loop nebula is the visible remnant of an ancient stellar explosion, this must have been a supernova outburst. When an ordinary nova explodes, it ejects only 10^{27} or 10^{28} grams, while most supernovae lose about one solar mass, or even more if the pre-supernova is a very massive star. In a supernova outburst, a large fraction of the star's material is blown away.

But, at about the time of maximum brightness of a supernova, the velocity of expansion may be well in excess of 1,000 kilometers per second. Since at the present time the Loop nebula is expanding at probably only 45 kilometers per second, there must have been a drastic deceleration during the lifetime of the nebula. Both Zwicky and J. H. Oort have attributed this slowing down to the resistance by the interstellar clouds with which the expanding nebula has collided.

Oort has computed the deceleration experienced by a shell of gas, having a mass of the order we have found for the loop, as it expands at 1,000 kilometers per second and pushes along the interstellar gas which it encounters. His result is that after 5,000 years the velocity would be halved, and after almost 30,000 years it would be only about 100 kilometers per second. At this "age" the diameter of the nebula should be about 50 light-years, just about that of the Cygnus Loop. The latter, however, is now expanding at only some 45 kilometers per second. The discordance between the observed 45 and the computed 100 kilometers per second could be removed if the initial velocity were less than 1,000 kilometers per second, or if the interstellar clouds were somewhat denser than Oort assumed. The

NGC 6960, the western arm of the great Cygnus Loop, as photographed many years ago at Mount Wilson Observatory. In this picture the motion of the nebulosity is to the right. The smaller number of stars in the right-hand half indicates the presence of an interstellar dust cloud.

latter change would not be unreasonably large. It would then seem that the Loop nebula could well be about 30,000 years old, rather than 160,000 years, but it can hardly be much younger than this.

The wispy appearance of the Loop nebulosities strongly suggests that they are the visible result of the collision of the expanding shell with interstellar clouds. A conspicuous dark cloud can be seen outside NGC 6960. This is easily recognized on the Mount Wilson photo on page 117; note the lessened number of stars to the right of the nebula. According to Oort, the thinnest wisps are only about 700 astronomical units across.

But is the luminosity of the wisps really caused by collisional excitation, as Oort and J. W. Chamberlain have thought? In 1955, Minkowski studied the intensities of the Balmer emission lines of hydrogen in the spectrum of the Loop nebula. He found that the relative brightnesses of these lines could be explained only by radiative excitation, that is, by the nebula shining because its atoms have absorbed ultraviolet light that has come from a very hot star. However, careful searches by L. Aller at Lick Observatory, and by A. Wachmann at Bergedorf Observatory, failed to show near the center of the loop any very hot star of apparent magnitude 12.5 or brighter. Other observers have demonstrated that there is insufficient interstellar absorption to obscure such a star.

Minkowski suggests that we have failed to recognize the hot star that stimulates the nebula to shine because it is the fainter component of a close double star, masked by its visually brighter primary. He points out that it would be practically impossible to prove that the 7th-magnitude *B7* star near the center of the ring does not have a somewhat fainter, much hotter companion. If Minkowski's conjecture is correct, the stellar remnant of a supernova that flashed up perhaps 30,000 years ago may still be in existence among the stars of the Milky Way.

What was the Loop nebula like during its earliest stages? Oort invites a comparison of it with the Crab nebula, which is only about 900 years old and still much smaller than the Cygnus Loop. The Crab nebula, also known as Messier 1, is located near Zeta Tauri, and is a familiar object to amateur observers with moderate-sized telescopes.

The Crab nebula in Taurus was found by the French comet hunter Charles Messier in 1758, and is the first object in his famous catalogue. But it may have been seen as early as 1731 by the English amateur, John Bevis.

It originated in the year A.D. 1054 from the outburst of a supernova which at maximum was brighter than Venus, and remained visible to the naked eye for two years. This star was widely observed in China and Japan, but there do not seem to be any European records of it.

The nebula that started expanding in 1054 is still growing in radius at a rate of 0.21 second of arc per year, with indications of only a slight deceleration. Radial velocity measurements by N. U. Mayall show that the linear rate of expansion is 1,300 kilometers per second, probably not much less than the original rate.

The central star of the Crab nebula is now of apparent magnitude +16, but it may have become as bright as −6 in 1054, corresponding to an absolute magnitude of −16 then, and of +6 now. At the present time the angular radius of the Crab nebula is some 180 seconds of arc, or about three light-years, since the distance is 4,000 light-years.

Oort concludes from these facts that about 30,000 years from now the Crab nebula will resemble the great Cygnus Loop, as seen from four times the latter's distance. Our comparison between the two objects will be pursued further next month.

QUESTIONS... FROM THE S+T MAILBAG

Q. Which of *Sky and Telescope's* star charts should be used for twilight observations of bright artificial satellites this month?

A. This question is answered under the star chart on page 157 of this issue.

Q. Are there any stars other than the sun with planetary systems?

A. So far, the solar system has no observed counterparts. A planet similar to Jupiter would probably not be detectable by existing methods, even if it revolved about one of the nearest stars.

Q. Why do faint telescopic stars appear whitish rather than their actual colors?

A. Faint light does not stimulate the cones of the eye's retina, which perceive color, but only the more sensitive rods, which are color-blind.

Q. What is a parsec?

A. It is the distance at which the average radius of the earth's orbit around the sun (93 million miles) subtends an angle of one second of arc. In other words, a star at this distance would have a *par*allax of one *sec*ond. A parsec is equal to 3.262 light-years, or about 19.16 trillion miles.

Q. Why does the latest sunrise occur on January 5th, for latitude 40° north, instead of at the time of the winter solstice?

A. Because the equation-of-time effect counterbalances the lengthening of daylight, for about two weeks after the solstice. During that time, the sun loses about half a minute each day in crossing the meridian, while moving northward in the sky less than a degree.

Q. Is Pluto considered a planet or a moon?

A. Pluto is a planet, an independent body moving in its own orbit around the sun. There is some evidence that this outermost planet may have been a moon of Neptune at one time.

W. E. S.

RADIO SPECTROHELIOGRAPH AT STANFORD UNIVERSITY

In a few months, the Radio Propagation Laboratory of Stanford University expects to place in operation a new microwave spectroheliograph. The project is under the direction of Prof. Ronald N. Bracewell, formerly with the Commonwealth Scientific and Industrial Research Organization at Sydney, Australia.

Thirty-two 10-foot paraboloidal antennas are being set up in a two-acre meadow to form a cross 350 feet long, an arrangement similar to the Mills cross radio interferometer. This will give the scanning resolution of a single 350-foot dish, but only a fraction of its sensitivity to faint radio sources.

The purpose of the instrument is to scan the sun at a wave length of 10 centimeters in order to detect the radio output of the chromosphere, the layer of gases just above the sun's photosphere. The large size of the apparatus and the smallness of the wave length will permit distinguishing areas as small as 3/1,000 of a square degree.

Since the antenna will scan the sun in much the same way that a television camera's electron beam scans the image of its subject to produce a picture, and since this will be done in radiation of a single wave length, the result will be a radio spectroheliogram. The 32 component antennas will look at the sun in unison, completing a scan of the entire solar disk every two hours. As with most other types of radio telescopes, clouds will not prevent solar observations.

The project has been supported by the Air Force Office of Scientific Research and Stanford Research Corp.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 98th meeting of the American Astronomical Society at Urbana, Illinois, in August, 1957. Complete abstracts will appear in the Astronomical Journal.

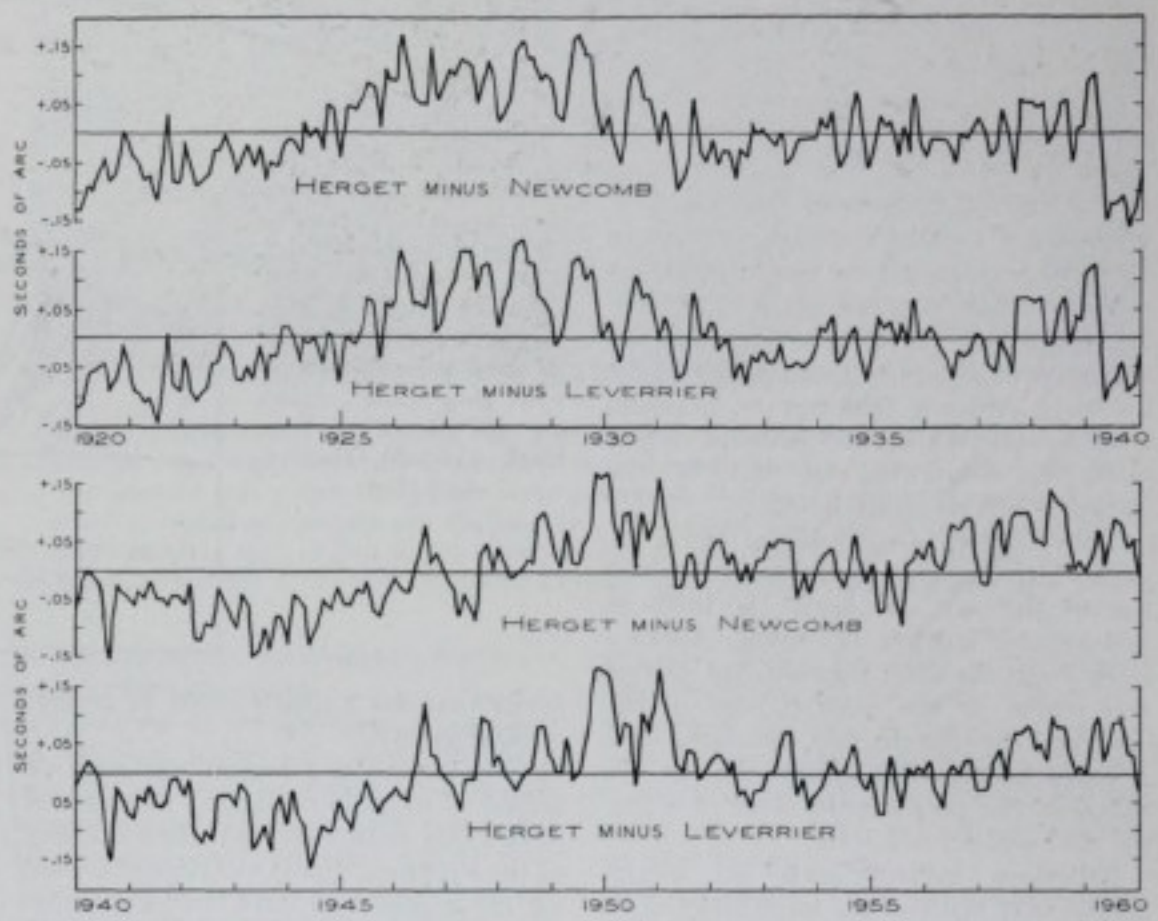
Tests of the Solar Ephemeris

The last two astronomers to develop in extreme detail the mathematical formulae for the orbital motion of the earth were Leverrier in 1858 and Newcomb in 1898. The latter's tables are the basis of the positional ephemeris of the sun still in use.

As noted on page 581 of *Sky and Telescope* for October, 1957, R. L. Duncombe and G. M. Clemence, U. S. Naval Observatory, have carried on a searching comparison of Newcomb's solar tables with a numerical integration of the earth's motion by Paul Herget, Cincinnati Observatory, for the years 1920 to 2000.

The latest step in the Washington astronomers' analysis has been a study of the earth's orbital longitude and radius vector. One of the most important corrections to Newcomb that they have found is that his value for the rate of diminution of the eccentricity of the earth's orbit is in error by three per cent. A number of small periodic errors in Newcomb's predictions for the longitude of the sun were also discovered, some amounting to a few hundredths of a second of arc in a period of a few months, and some of 1/10-second extent in periods up to 12 years. There are analogous small discrepancies in Newcomb's formulae for the radius vector of the earth. Similar faults affect Leverrier's theory, for both he and Newcomb in their calculations had in general neglected second-order perturbations.

These results strengthen the conviction of the Washington astronomers that Newcomb's theory of the sun is not sufficiently precise for all present requirements, and that his work must be repeated and extended.



For the years 1920 to 1960, Paul Herget's precise predictions of the sun's celestial longitude are compared with earlier work by Leverrier and Newcomb. The vertical scale gives the small differences in fractions of a second of arc. These discordances have been traced to minor imperfections in the older tables of the sun's apparent motion, which need revision. U. S. Naval Observatory diagram.

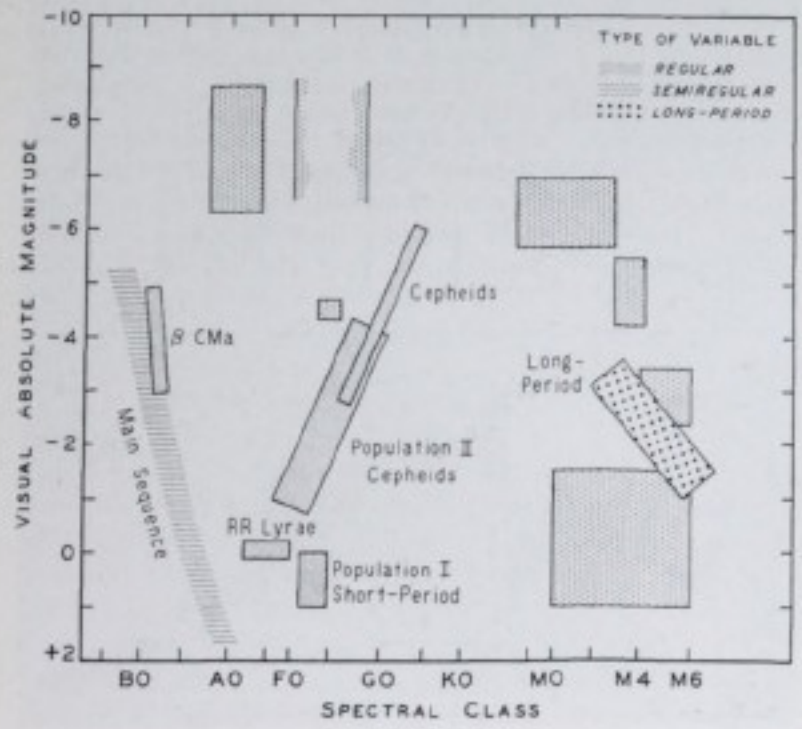
Variability of Supergiant Stars

For many years it has been known that all red supergiant stars of spectral type *M* are variable in brightness, a fact established by photoelectric measurements of brightness at Washburn Observatory. And in the spectral types *F* and *G*, the Cepheids are examples of yellow supergiant variable stars. These facts have led H. A. Abt, of Yerkes and McDonald Observatories, to inquire whether the high-luminosity stars of early spectral types might not also be generally variable.

Dr. Abt's plan was to measure radial velocities rather than brightnesses, since for all intrinsically variable stars the light variations are accompanied by line-of-sight velocity changes. Nine *A*- and *F*-type supergiants were observed with the coude spectrograph of the 82-inch McDonald reflector, at a dispersion of 8½ angstroms per millimeter. Dr. Abt observed each of these stars on all possible nights during a one-month interval in the fall of 1956.

All nine stars showed distinct fluctuations in radial velocity of a semiregular character. The largest range was for the star 6 Cassiopeiae, whose velocity of approach changed by as much as 18 kilometers per second. The nature of the velocity variations suggests that these stars are pulsating in cycles ranging in length from a few days to a few weeks.

A survey of variables in the upper part of the spectrum-luminosity diagram has been made by Dr. Abt, and the chart shown here is based on his diagram in the *Astrophysical Journal* for July, 1957. He



The rectangles in this spectrum - luminosity diagram indicate different kinds of intrinsically variable stars. H. A. Abt has added the new group of variables in the upper left part, among the very hot supergiant stars. Adapted from the "Astrophysical Journal."

concludes that probably all the stars in the region brighter than absolute magnitude +1 and to the right of the main sequence are variable in magnitude and radial velocity. The variability is most pronounced in light on the right side of the diagram and in velocity on the left, but in all cases it is probably due to pulsation in some form.

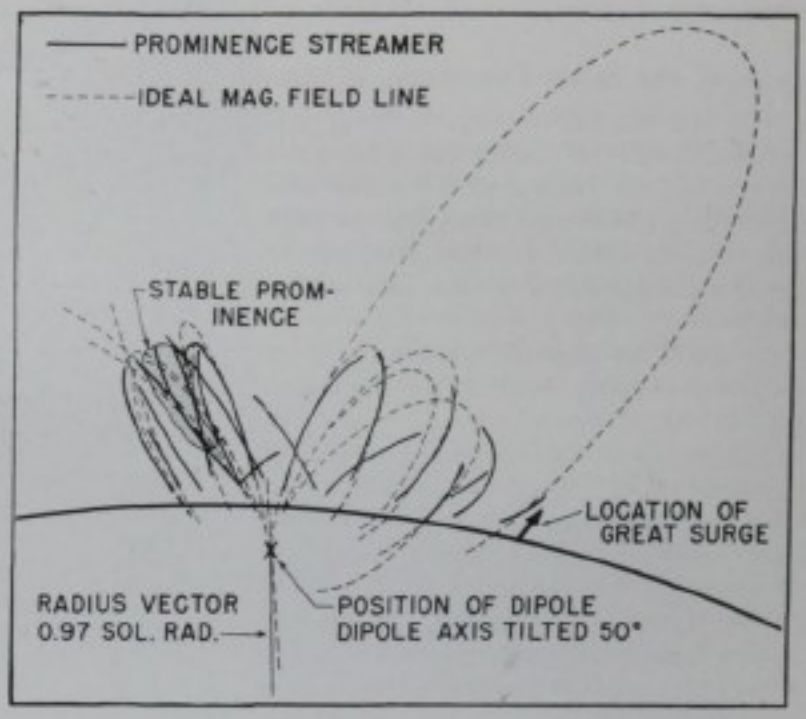
Prominence Motions and Solar Magnetic Fields

The arching motions of the gases in a prominence seen at the edge of the sun have long suggested to astronomers the action of solar magnetic fields. The association of these phenomena has now been made more definite by two astronomers at the High Altitude Observatory, Malcolm Correll and Walter O. Roberts, whose work was supported in part by the National Science Foundation.

They selected an important active region which had crossed the central meridian of the sun on April 13, 1950, in heliographic latitude 14° north. About a week later, the sun's rotation had carried this region to the western edge of the disk, and the prominences associated with it could be observed against the sky. In this case, the prominences were of a simple and well-defined form.

Laborious measurements on photographs were made of the trajectories of all visible details of the prominences over a three-day interval. The motions were of homogeneous character to heights of 70,000 kilometers above the solar surface, and extended 90,000 kilometers in latitude away from the center of the active region.

The assumption that the knots of prominence material were moving along the lines of force of a localized magnetic field allowed the properties of this field to be deduced. It was found that the observations could be explained satisfactorily by the field of a magnetic dipole, located about 3/100 of a solar radius beneath the surface, with its axis tilted 50 degrees toward or away from the observer. About 80 per cent of the streamers appeared to conform to these hypothetical lines of force. The fit was considerably better than for a dipole tilted 40 degrees or 60 degrees.


PROMINENCE STREAMER
IDEAL MAG. FIELD LINE
STABLE PROM-INENCE
LOCATION OF GREAT SURGE
RADIUS VECTOR 0.97 SOL. RAD.
POSITION OF DIPOLE DIPOLE AXIS TILTED 50°

In the solar prominence of April 20, 1950, observed motions of prominence material were along the solid lines. The dashed curves are lines of force in the magnetic field believed to have been associated with this active region on the sun's surface. High Altitude Observatory chart.

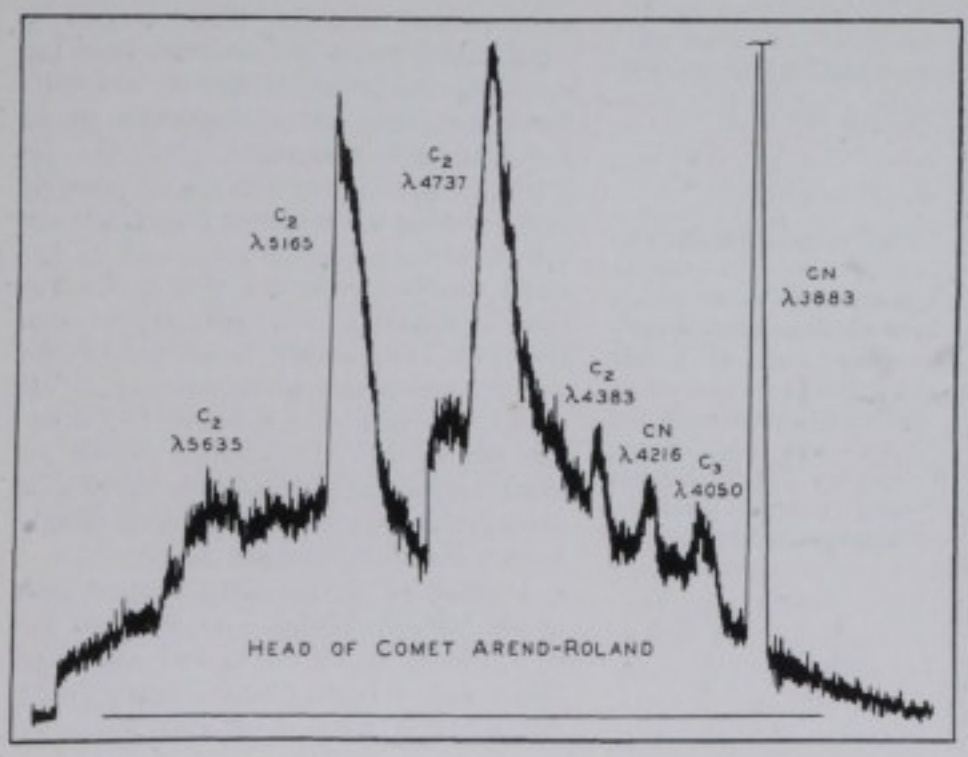
This same active region was also observed by its radio radiation. The date of peak radio noise occurred when the axis of the supposed dipole was aligned toward the earth, and four days later a geomagnetic storm of major proportions took place.

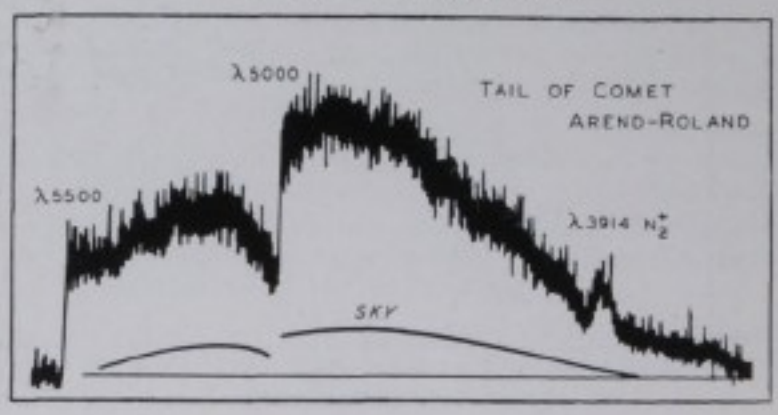
Comet Arend-Roland (1956h)

University of Michigan astronomers presented three papers to report their varied observations of Comet Arend-Roland. This is the object two Belgian observers discovered in November, 1956; it became as bright as 2nd magnitude in the evening sky during the following April.

Freeman D. Miller described the rapid changes in the comet's tail structure, as shown by direct photographs taken with the 24-36-inch Curtis Schmidt telescope at Portage Lake, Michigan. On the night of May 4-5, 1957, he obtained a series of 17 plates, each exposed for eight minutes, with the midexposure times averaging 22 minutes apart. These photographs show quick variations in the complex structure of the tail. The most remarkable feature was a bright disturbance about 300,000 kilometers in extent, which moved rapidly outward along the tail, away from the sun.

This motion may be seen in the accompanying enlargements of a small portion of the tail, taken from three successive exposures. The feature shaped like a hockey stick was moving rapidly across the starry background. About half of this displacement was due to the motion of the entire comet relative to the earth; the remainder represented an actual recession of the disturbance from the nucleus of the comet at a rate of 53 kilometers per second. Similar speeds have been measured in other comets. Two independent methods of calculating the acceleration relative to the nucleus gave 53 and 86 centimeters per second each second.





William Liller's spectrum tracings of Comet 1956h on April 29, 1957. The feature at 3914 angstroms in the tail spectrum is from an aurora in the earth's atmosphere; the dip at 5000 angstroms was caused by a yellow filter through which longer wave lengths were scanned. Both spectra show a background of reflected sunlight, but only the head has bright bands of carbon and cyanogen. Each tracing took about 12 minutes, through a spectrograph slit 42 angstroms wide for the head and 107 for the tail. University of Michigan charts.

Dr. Miller's photographs also show marked changes in the fan of narrow rays that extended up to two million kilometers from the nucleus, in a direction away from the sun. The ray pattern changed conspicuously from one exposure to the next, completely altering in two hours. Rays a million kilometers long could develop within half an hour.

Several possible mechanisms might account for the rapid formation of these streamers, but Dr. Miller regards no one of the hypotheses as entirely adequate. They include ejection of a jet of gas from the nucleus, and the localized brightening of the diffuse tail when a narrow pencil of corpuscular radiation from the sun passes through it.

The spectrum of Comet Arend-Roland was photographed with the University of Michigan's 37-inch reflector at Ann Arbor by T. P. Stecher and D. B. McLaughlin. Between April 24 and June 3, 1957, they obtained 13 spectrograms with a fast new quartz-prism spectrograph, and four others with an ordinary two-prism spectrograph.

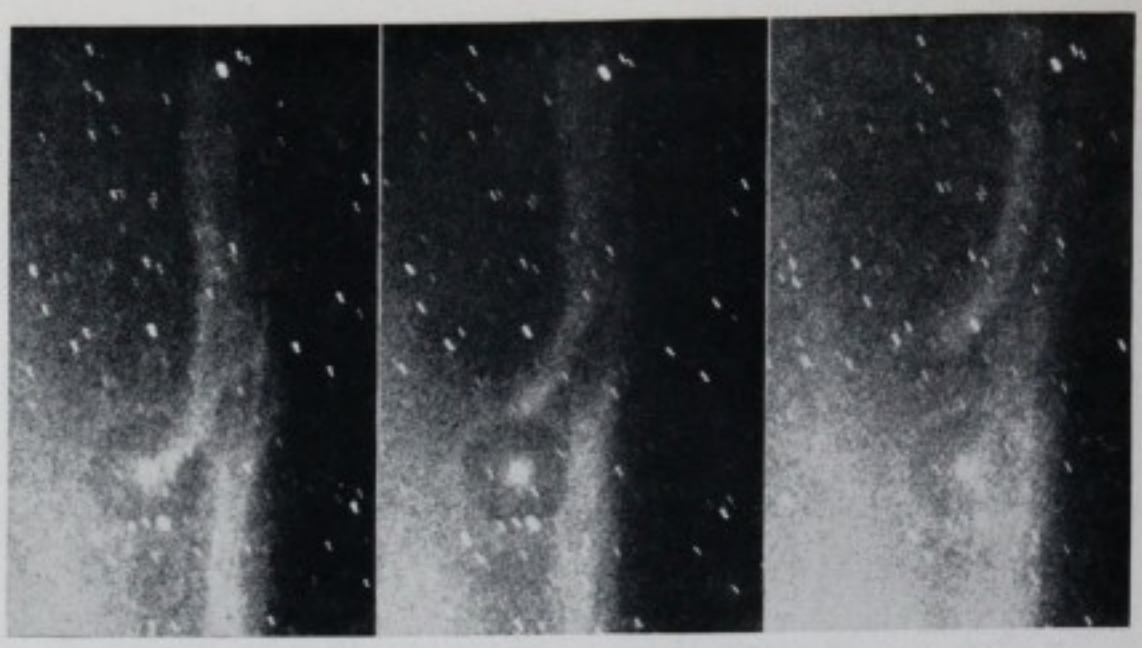
During the entire interval, the continuous spectrum due to reflected sunlight was unusually strong. The most intense emission feature was the cyanogen band at 3883 angstroms. Other molecules and radicals that could be identified by their emission bands included OH, NH, C_2, and C_3.

The same two observers used a 4-inch Ross camera on April 26th to secure an objective-prism photograph of the long sunward secondary tail of Comet Arend-Roland. (For a discussion of this tail, see *Sky and Telescope*, July, 1957, page 426.) This low-dispersion spectrogram showed a continuum which was brightest near wave length 4700 angstroms.

The third of the Michigan reports was by William Liller, who used the Curtis Schmidt telescope to obtain photoelectric tracings of the spectrum of the comet. His observations were on eight nights from January 23 to June 3, 1957, with a direct-recording spectrometer placed at the Newtonian focus of the telescope. Dr. Liller described in detail his tracings of the spectrum in different parts of the main tail, from 3400 angstroms in the ultraviolet to 6400 in the red.

The spectrum of the tail showed no emission bands, but only a continuous background having the color distribution of a dwarf *K*5 star. If this continuum is sunlight scattered by small spherical particles, their average diameter will fall between 0.5 and four microns, depending on their composition.

At a distance of 1.7 million kilometers from the head, the observed surface brightness of the comet's tail could be produced by particles of such size if their average separation was about eight meters. From this, Dr. Liller could estimate the total mass of the visible tail as of the order of 10^{16} grams.



Rapid motions outward along the tail of Comet Arend-Roland (1956h). The left of these eight-minute exposures is an enlargement of a part of the view at the foot of this page; the others were obtained 21 and 44 minutes later. The scale is 16,000 kilometers per millimeter. About half the shift of the kink with respect to the stars is due to the comet's motion, the rest to drift of matter along the tail. Similar drifts have occurred in other comets, including Halley's in 1910.

Comet Arend-Roland on May 5, 1957, at 2:52 Universal time. This eight-minute exposure on a 103a-O plate was obtained by Freeman D. Miller with the Curtis Schmidt telescope at the University of Michigan. In this 1.3-fold enlargement, the scale is 46,000 kilometers per millimeter. The "hockey-stick" marking shown further enlarged at the top of the page is here 1¼ inches above and to the left of the comet's nucleus. Photographs on this page were provided by the University of Michigan Observatory.

Is Saturn a Radio Source?

At Yale University Observatory last winter, Harlan J. Smith and James N. Douglas began an experimental program of long-wave radio observations of planets. They used equatorially mounted Yagi antennas instead of a conventional dipole array, to take advantage of their relatively high gain and easy steerability. The pair of four-element Yagis worked at 21.07 megacycles, and were operated as a phase-switching interferometer.

They were mounted 2.3 wave lengths apart on the roof of Hendrie Hall, on the Yale campus in New Haven, the building where the college's undergraduate radio work is centered. Students assisted with the observations, which could usually be made only after midnight, owing to severe man-made interference at that frequency.

The equipment was first tried on Jupiter, its radio-emission pattern turning out to be similar to those found by other investigators. Saturn was the next object observed, with rather surprising results. Disturbances were recorded, many of them more distinct, longer lasting, and fitting the antenna interference pattern

better than those of Jupiter. The data suggest a possible rotational period for Saturn of about 10 hours 22 minutes. This would correspond with the rotation rate indicated by a white spot observed on the planet in 1946, at a latitude of 12°.5 south.

The Yale astronomers regard their results as tentative, because of the short period of the observations (March 28, 1957, to the end of May), the unknown effect of terrestrial atmospherics, and the coarseness of their antenna pattern.

PLASMOIDS

A gaseous mixture of electrically charged particles (ions) and electrons is called a plasma. Little blobs of plasma, created in laboratory experiments, have unusual properties that may explain some of the phenomena of the sun and other stars. These experiments are described by Winston H. Bostick, Stevens Institute of Technology, in *Scientific American*, October, 1957.

Dr. Bostick has been studying magnetically confined plasmas of deuterium (heavy hydrogen) generated with a special plasma gun. It has two closely spaced electrodes made of titanium, with the heavy hydrogen absorbed in them. A pulsed-arc current of several thousand amperes, each pulse lasting about half a millionth of a second, is passed across the gap between the electrodes.

This high current evaporates electrons and ions from the electrodes, and also generates a magnetic field which pinches the plasma into a slender column. The special feature of the gun is that the plasma arching out from the electrodes is bent into a loop, which finally detaches itself as the current pulse dies, and assumes somewhat the appearance of a smoke ring.

The strong magnetic pressure on the inside of the loop blows the plasma forward at high speed – up to 120 miles per second, comparable to the speeds of stars in galaxies and of solar flares. Under certain conditions, the plasmoids form a pair of rings that repel each other strongly. These may be analogous to magnetohydrodynamic whirls that perhaps form in pairs in the interior of the sun, causing the appearance of sunspots on its surface, according to the Swedish astronomer, H. Alfven.

The magnetohydrodynamic behavior of plasmoids is at once very simple and very complex. Dr. Bostick suggests that the combination of plasma and magnetic field makes a kind of self-shaping putty, whose forms may help us understand the dynamics of such large aggregations of matter as stars and galaxies. At the other end of the scale, we may learn more of the structure of fundamental particles, such as electrons, protons, mesons, and the like. Perhaps an electromagnetic field and its own gravitational forces, working together, may actually create such particles.

Amateur Astronomers

A Basement Planetarium

SINCE I wanted to plot and pierce the star holes in the plastic globe myself, I bought an unperforated Spitz Jr. model projector for my basement planetarium. The early winter months of 1955-56 were spent making the holes, including all stars down to magnitude 4.5 and many fainter ones. All the constellations were portrayed. The right ascensions and declinations were plotted directly on the globe by means of paper scales.

The following summer the dome was constructed, a metal frame covered by paper sheets. Its 50-inch diameter can accommodate four persons comfortably, although there have been seven or eight on occasion. The effect of day and night is created on the dome from two lamps giving blue light controlled by rheostats.

Yellow cellophane imparts a realistic color to the image of the sun from a special projector, and the moon projector has a rotatable metal disk with openings for the phases. Both the solar and lunar projectors are on miniature equatorial mountings, adjustable for latitude, declination, and diurnal rotation.

As the planetarium can show the heavens visible to an observer anywhere in the Northern Hemisphere, I can demonstrate the phenomenon of the midnight sun in arctic regions. The sun's daily path at different latitudes and for any season of the year can be shown. The eastward movement of the moon among the stars and other aspects of the sun and moon may be reproduced.

George Lovi's basement planetarium has a normal seating capacity of four.

Although small and simple to build, this planetarium has aroused much interest among my friends and neighbors. Last summer I had so many visitors at times that I feared my dome would not see another tomorrow.

GEORGE LOVI
408 Forest Ave.
Lakewood, N. J.

THIS MONTH'S MEETINGS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. Jan. 10, Dr. Fred Hoyle, Cambridge University, "Problems in Cosmology."

Dallas, Tex.: Texas Astronomical Society, 8 p.m., Dallas Health Museum. Jan. 27, astronomical films.

Detroit, Mich.: Detroit Astronomical Society, 2:30 p.m., State Hall, Wayne University. Jan. 12, Rev. Norbert J. Ruth, Assumption University, Windsor, Ontario, "Education and Astronomy."

Grand Rapids, Mich.: Grand Rapids Amateur Astronomers Association, 7:30 p.m., Grand Rapids Public Museum. Jan. 17, motion picture, "The Strange Case of Cosmic Rays."

Madison, Wisc.: Madison Astronomical Society, 8 p.m., Washburn Observatory. Jan. 8, Dr. A. E. Whitford, Washburn Observatory, "Twenty-five Years at Wisconsin."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Jan. 8, motion picture, "Our Mr. Sun."

Plainfield, N. J.: Amateur Astronomers, Inc., of Union County, 8 p.m., Stillman School auditorium. Jan. 17, Shirley I. Gale, American Museum-Hayden Planetarium, "The Origin and Destiny of the Universe."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Jan. 4, Francis J. Heyden, S. J., Georgetown University Observatory, "Photographing the Milky Way."

REGIONAL MEETINGS

Dallas, Texas, was the scene for the October 19-20 convention of the Southwest Region of the Astronomical League. Ten societies were represented among the 84 registered amateurs. Officers for the coming year are: Ted F. Gangl, Dallas, chairman; Clifford Wayland, Henderson, Texas, vice-chairman; James M. McMillen, Ft. Worth, secretary-treasurer; and E. M. Brewer, Dallas, regional representative.

The Great Lakes Region met at Columbus, Ohio, July 5-6, with over 100 members present. This year's officers are: Mrs. Jane Gann, Columbus, chairman; Charles Strull, Louisville, Kentucky, treasurer; Mrs. Olive Grunow, Detroit, Michigan, secretary; and Charles S. Johnson, Detroit, regional representative.

NEWS NOTES

FIRE NEAR MT. WILSON

Because Mount Wilson Observatory is on a dry, wooded summit, the risk of forest-fire damage is great. As recently as 1953 a widespread blaze was checked before it reached the observatory grounds.

On Friday, November 22, 1957, the radio and press carried news of a very large forest fire in the Angeles National Forest, not far from Mt. Wilson. Tens of thousands of acres were burned, and at one time 1,500 fighters battled the blaze, which was whipped by strong winds.

This fire, however, did not get within about seven miles of the observatory. When it worked its way over to Monrovia Peak, it ran into the burn of the 1953 fire and could go no farther in that direction. A change in the wind stopped its progress through West Fork, the canyon to the north and east of the observatory. The construction crew and observatory shop men had gone up the mountain to help in evacuation, but it was deemed not necessary.

ASHEN LIGHT OF VENUS

Visual observers of the planet Venus occasionally see its night side as faintly luminous, an appearance resembling the earthshine shown by the moon in its crescent phases. There is no generally accepted explanation for this ashen light.

The rarity of this phenomenon has been much exaggerated, according to R. M. Baum. In the August, 1957, issue of the *Journal* of the British Astronomical Association, he has collected and summarized 37 reports of the ashen light, some referring to repeated sightings, from the years 1643 to 1895. The earliest of these reports, however, was interpreted by the observer himself (Riccioli) as probably due to chromatic aberration in his telescope. The next oldest known observations were by William Derham, canon of Windsor, who called the effect the "secondary light" of Venus. His fellow observer with "an excellent glass" saw it during the total solar eclipse of May 2, 1715.

UNIVERSITY OF MICHIGAN 85-FOOT RADIO TELESCOPE

The erection of a new radio telescope, 85 feet in diameter, is scheduled to begin in March near the University of Michigan campus at Ann Arbor. When it is completed by early summer, the instrument will first be used to observe the sun, later it will explore the Milky Way and other stellar systems.

The paraboloid will have a surface accuracy of $\frac{1}{4}$ inch, and will be able to make precise observations in winds up to 45 miles per hour. In its stowed position, the antenna will resist hurricane winds.

The equatorially mounted "dish" will need only a $\frac{1}{4}$-horsepower motor for tracking celestial objects at the sidereal rate. Heavier motors will be required for rapid pointing of the antenna, and it will have a 140-degree swing in declination, from the north pole to the southern horizon.

Approximately 320,000 pounds of structural steel and aluminum will go into the tower structure. The telescope is being designed and built by the Blaw-Knox Co., Pittsburgh, Pennsylvania, for the University of Michigan, under a contract with the Office of Naval Research.

IN THE CURRENT JOURNALS

SELECTION OF OPTICAL GLASSES IN APOCHROMATS, by N. v. d. W. Lessing. *Journal* of the Optical Society of America, October, 1957. "The problem of the selection of optical glasses for apochromats is treated by Conrady and a useful method of selection has been developed by Herreros. A shorter method, giving those glasses which yield the smallest possible powers, is presented in this paper."

MEASURING GEOLOGIC TIME, by Adolph Knopf, *Scientific Monthly*, November, 1957. "Before the beginning of the Paleozoic era there was a vast stretch of time, possibly 4,000 million years long. Eight-ninths of geologic time had already passed before there began that portion of the earth's history which is generally held to be the most significant."

GIANT DISH USED TO TRACK SPUTNIK I ROCKET

The 250-foot paraboloidal reflector at Jodrell Bank Experimental Station in England can now be operated for the radar tracking of the artificial satellites. Within six hours of receipt of a cabled request from the Soviet Union, the giant antenna picked up the third-stage rocket of the first artificial satellite, even though it was more than 1,000 miles away. The positional data were transmitted to Russian scientists.

Progress in the construction of the world's largest radio telescope was described in *Sky and Telescope* for September, 1957, page 516.

Left: An architect's drawing of the 85-foot radio telescope to be built for the University of Michigan Observatory in Ann Arbor. At the time of completion, it will be one of the largest steerable radio telescopes operating in the United States.

Right: A night view of the now nearly completed 250-foot radio telescope at the Jodrell Bank Experimental Station, near Manchester, England. This picture, taken in November, was supplied by the British Information Services.

McDonald Observatory's 36-inch Reflector

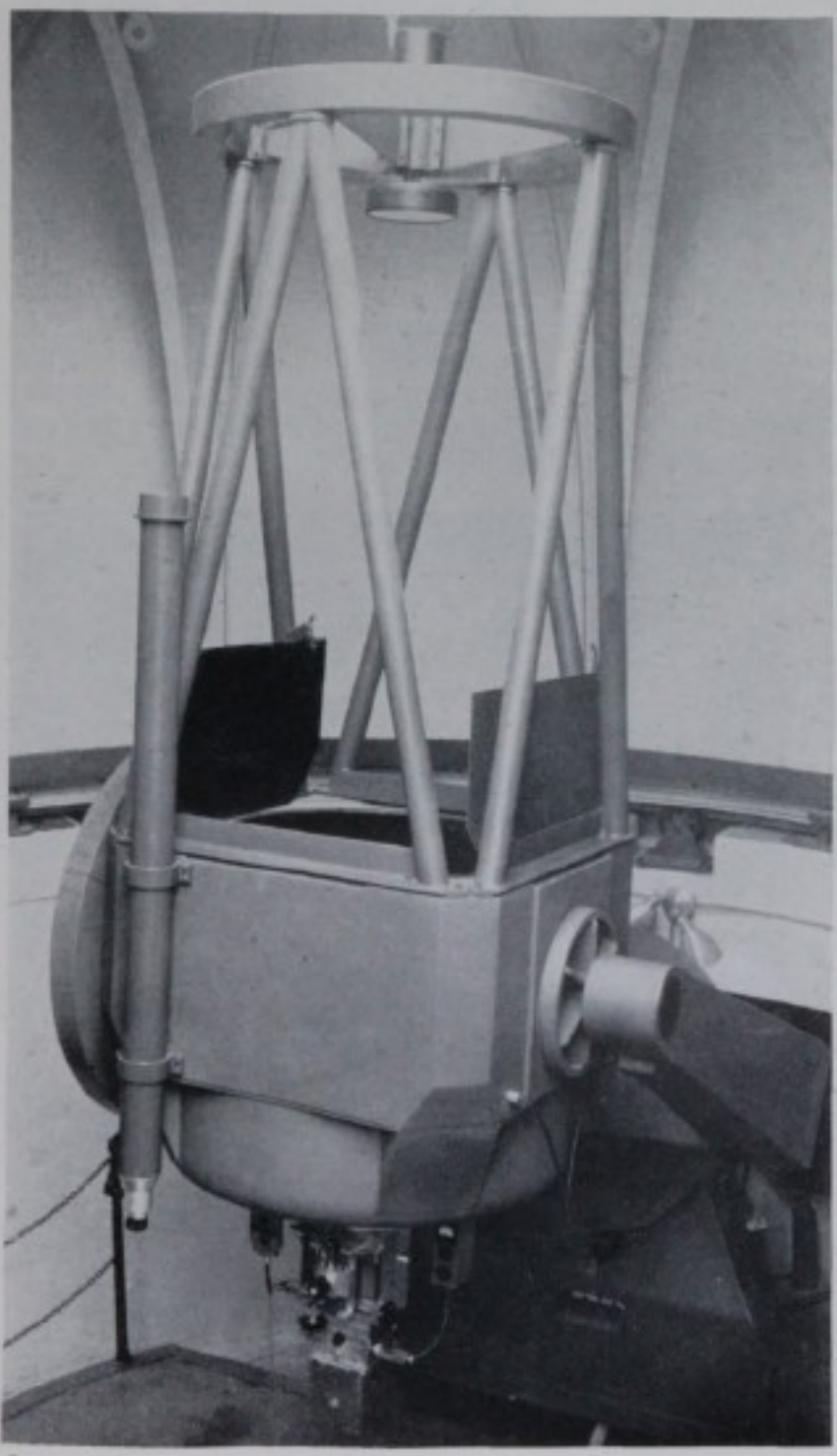
W. A. HILTNER, *Yerkes and McDonald Observatories*

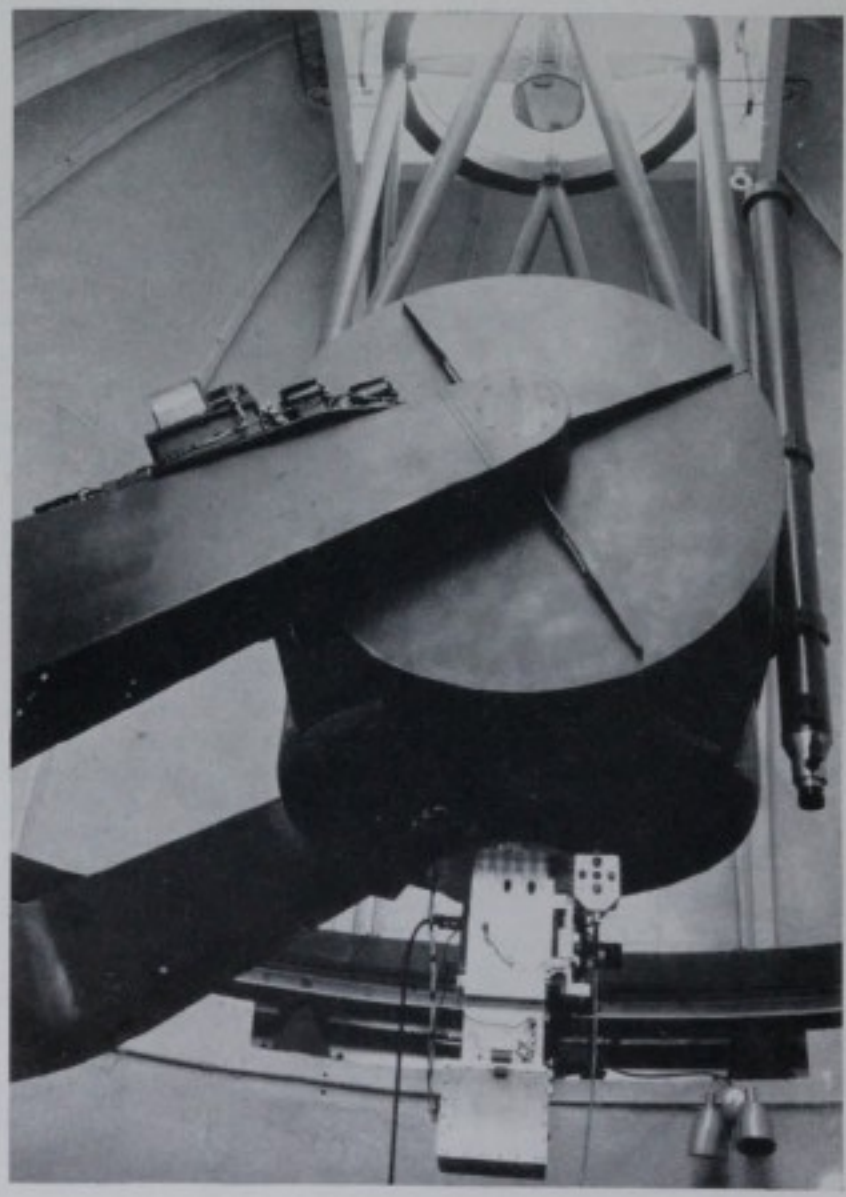
AT McDONALD OBSERVATORY, near Ft. Davis, Texas, the need for a second telescope of significant size has been evident for some years. As early as 1945, plans were considered for an instrument smaller than the 82-inch reflector, yet sufficiently large and well mounted that it could absorb some of the pressure on the big telescope. Hence, a 36-inch reflector of the Cassegrainian type was recently constructed.

A telescope working only at the Cassegrainian focus could be considered, since it is the experience of McDonald observers that for photoelectric photometry and low-dispersion spectroscopy the Cassegrainian focus is greatly superior to either the prime or the Newtonian focus. The loss of an additional 10 per cent of the radiation by the secondary mirror is more than compensated for by the greater observing convenience. This is especially true when a rising floor is provided.

Consequently, provision was made for the Cassegrainian focus only, which permitted using an easily constructed ellipsoidal primary and a spherical secondary. Focusing of the combination is accomplished by moving the secondary back and forth along the optical axis; motor controls for this are conveniently accessible on the primary mirror cell. The optics were made in the Yerkes Observatory optical shop by the late Fred Pearson.

The usefulness of a telescope of this size is greater than may be realized. Just a few years ago, the brightness measurement or photometry of an 18th-magnitude star was considered near the "limit" of the 100-inch reflector at Mount Wilson Observatory. Now, we observe to magnitude 22 or fainter with the 82-inch, which





Two views of the new 36-inch reflector at McDonald Observatory. At the left, the two halves of the primary mirror's cover are open, and the western arm of the mounting fork may be seen. On the eastern fork arm, seen at the right, are the motors that provide motions for setting and guiding in declination. The photometer is at the bottom. Hanging next to it is the paddle that carries the hand controls. Photographs by Glenn Burgess.

corresponds to approximately 20.5 with the new 36-inch reflector. This has come about through the development of new auxiliary equipment and, perhaps, a change in point of view.

Since the photoelectric process is linear we can compensate, at least in theory, for smallness in aperture by increasing the exposure or integration time of each photoelectric observation. Thus, telescopes of moderate aperture are very useful in photoelectric work, although the significance of large aperture should not be underestimated – a factor of two in aperture can be all-important in some work.

On the other hand, the smaller telescope cannot compete with larger ones in spectrographic work, primarily because of the nonlinearity of the photographic emulsion in contrast to the photoelectric cell. However, it may be just a matter of time and hard work before this handicap is likewise removed.

In an observatory with telescopes that complement each other, there is a primary requirement for the smaller one – it must be just as well mounted as the larger. Too often this is not the case. For our 36-inch mounting, designed by Joseph Nunn of Los Angeles, California, the fork type was selected for a variety of reasons: dome size, rapidity of operation, and the like. Observing near the pole is not a problem, however, since the clearance between Cassegrain mounting frame and fork is 34 inches at declinations greater than about +75°.

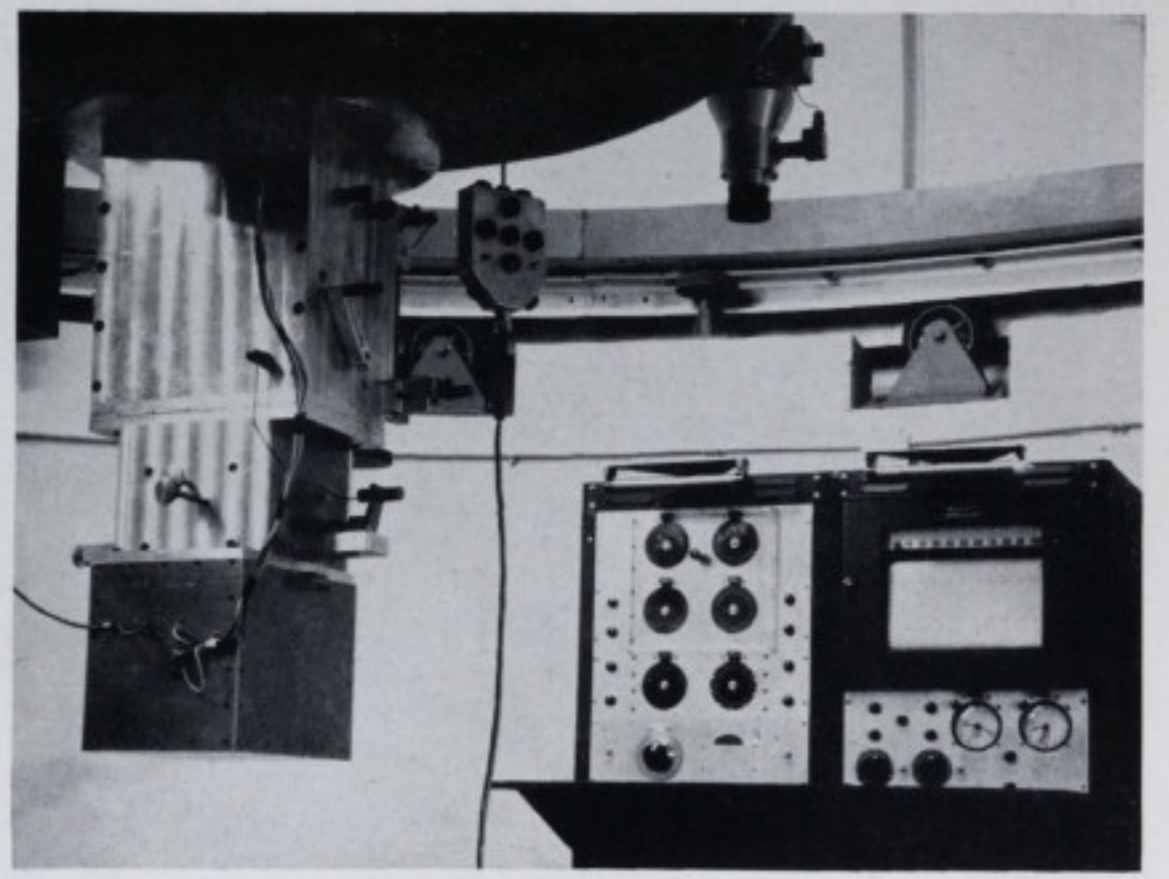
All motions of the telescope are achieved electrically. Three speeds are provided on each axis: the first for slewing at two degrees a second, the next for setting at two degrees a minute, and a guide-motion rate that is made variable by means of Metron units located between the guide motors and the drive units. All motors are equipped with an electrically operated brake. Flywheels are provided on the slew motors to control the acceleration, both positive and negative. It is especially important on this instrument to control the acceleration in order to reduce wear on the worm gears, for the same gears are used for the set, guide, and diurnal rates, as well as for the slew motions. All bearings are preloaded to provide an instrument free of backlash and, hence, with maximum ease in guiding.

At the north side of the rising floor is the control console, always in a convenient position. Dials indicate the telescope's pointing direction in right ascension, hour angle, and declination. Controls for the slew and set rates, as well as for dome rotation and floor height, are available on the console. The diurnal-drive rate is determined by a resistance-capacitance oscillator, where the frequency is controlled at the console by varying an air capacitor.

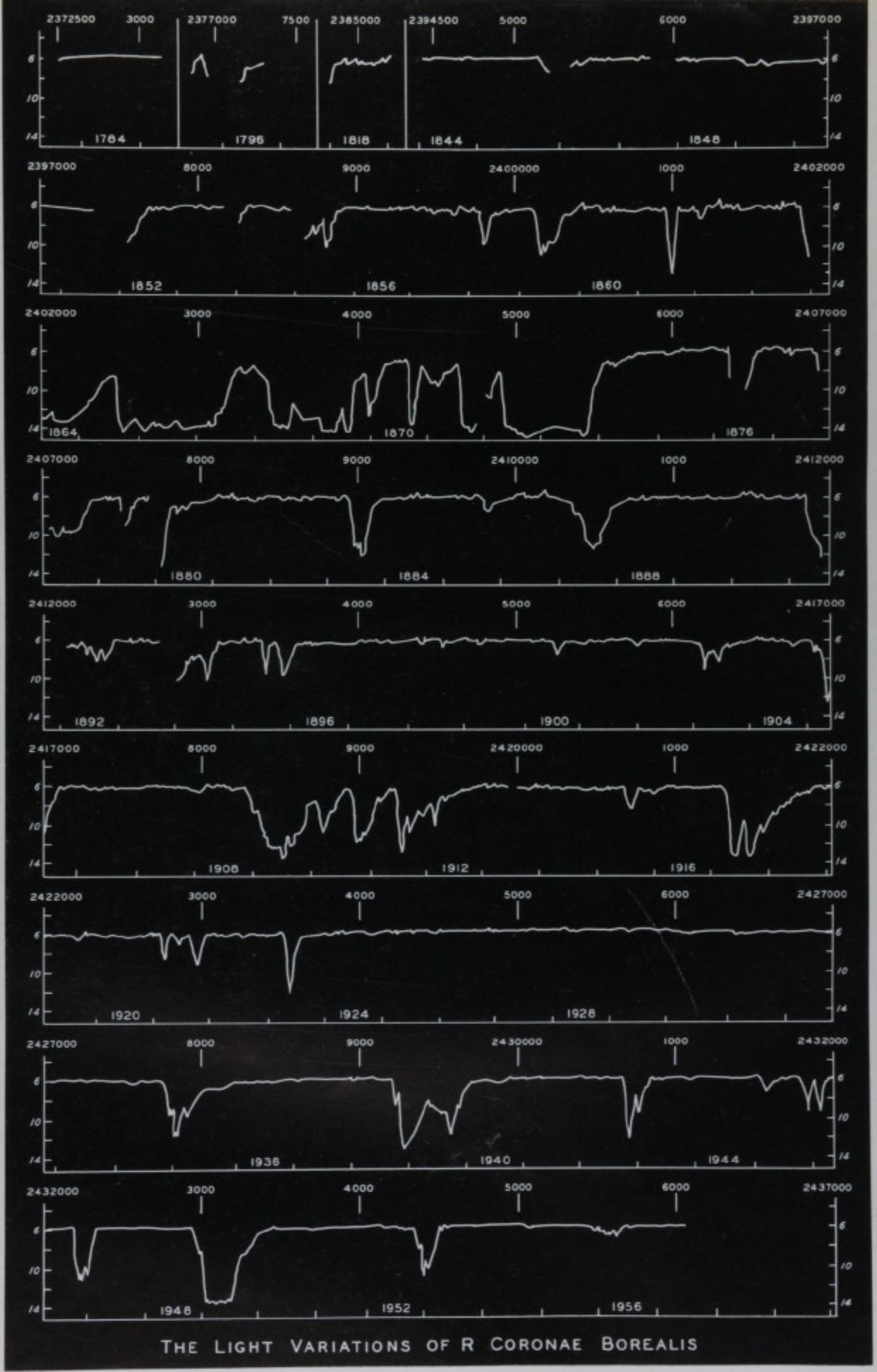
The console is equipped with a quartz-crystal oscillator that drives a synchronous motor for converting hour angle to right ascension. The diurnal rate can be compared with this sidereal frequency by a stroboscope. The sidereal frequency also operates a clock for sidereal time, and a universal-time clock is run by the line frequency. As is apparent from the picture, a Brown recorder is an integral part of the console.

At the left is the dome of the new 36-inch reflector, and the 82-inch dome is seen at the upper right. Twelve hours after the author took this photograph in mid-November, over three inches of snow fell on Mt. Locke, where the McDonald Observatory is located. The 82-inch reflector, completed in 1939, is the fourth largest telescope in the world, being surpassed in aperture only by the three California giants.

Normally hanging from a hook near the eye end of the telescope is a hand-held paddle that has controls for dome rotation, floor height, right ascension and declination settings, and guide motions. The same buttons are used for guide and set; a toggle switch selects the speed.



In the left part of this picture the three sections of the photoelectric photometer are seen. The first is an offset mechanism to enable the observer to set the photometer on invisible objects. The middle section contains the diaphragms for limiting the area of sky viewed by the photocell, together with color filters, and, when polarization measurements are made, an analyzer. The third section is an icebox for cooling the photomultiplier tube to minimize the dark current. The output of the photometer is fed into an amplifier system and the deflections are marked on the Brown recorder seen in the control console at the right. This console is attached to the frame that carries the observing floor. Photograph by Glenn Burgess, Alpine, Texas.



THE LIGHT VARIATIONS OF R CORONAE BOREALIS

Some Very Irregular Variable Stars

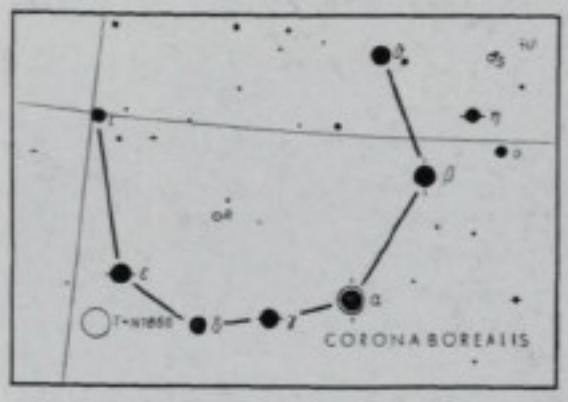
THOMAS A. CRAGG, *Mount Wilson and Palomar Observatories*

FEW observing programs for amateurs have greater value than the patrol of the light changes of the more notable extremely irregular variable stars. Of particular interest are those of the U Geminorum and R Coronae Borealis types.

Normally, U Geminorum stars remain at minimum light, most of them between 14th and 17th magnitude, faint enough to tax the largest amateur instruments. It is the maxima of these variables, however, that are of principal interest. Without warning, a U Geminorum star will brighten by as much as three to five magnitudes, frequently reaching peak brightness within 24 to 48 hours. It will often stay at maximum for as long as a week, then subside to its original minimum light in a few days or a week.

At present, there is no way to predict such an outburst. Some stars of this kind, such as SS Cygni, have occasional anomalous maxima: The star rises slowly to a low maximum, fluctuating very erratically in brightness for several weeks before settling down to a more expected behavior.

Seasoned amateur observers find U Geminorum stars tantalizing to watch. For many nights they spend much time and use all the tricks of observing just to suspect a faint glimmer where the star is supposed to be, only to find the next evening that it has become so bright the field is hard to identify.



A portion of the Skalnate Pleso "Atlas of the Heavens," with R Coronae Borealis marked by a small circle.

Little is known about the real nature of these variables. However, recent spectroscopic studies strongly suggest that the typical U Geminorum object is a double star system with very dissimilar components—a small blue star and a larger yellow one. Probably the blue star accounts for most of the light variation.

Z Camelopardalis stars resemble the U Geminorum variety, with more rapid activity, outbursts recurring in roughly 15 to 20 days. But a Z Camelopardalis variable may suddenly become inactive, remaining constant for a long interval, being "stuck" at some place on the light curve.

Contrary in behavior to the U Geminorum stars, those of which R Coronae Borealis is the prototype are normally at maximum light, fading at wholly unpredictable intervals. The brightest is R Coronae Borealis itself; at maximum it is of magnitude 5.8, just visible to the unaided eye.

The changes in brightness of an individual R Coronae Borealis star are usually very great, in some cases eight to 10 magnitudes. They consist of a rapid fading over several weeks, followed by a recovery that often requires months. Generally, the rising branch of the light curve is more irregular than the descent. Months or years may elapse before the next drop to minimum occurs; R Coronae Borealis once remained unchanged at maximum for 10 years, as shown by the light curve on the opposite page.

SU Tauri, a famous member of this group, began to fade toward the end of 1955, dropping from magnitude 9.1 to 15.5 in about two months. After remaining at minimum for a while it began to brighten, reaching magnitude 12 before the sun interfered with observations of its part of the sky. When SU Tauri was seen again, in the morning sky in June, it had fully recovered and was of normal 9th magnitude.

Spectroscopic observations show that the atmospheres of these stars are rich in

SOME R CORONAE BOREALIS VARIABLES

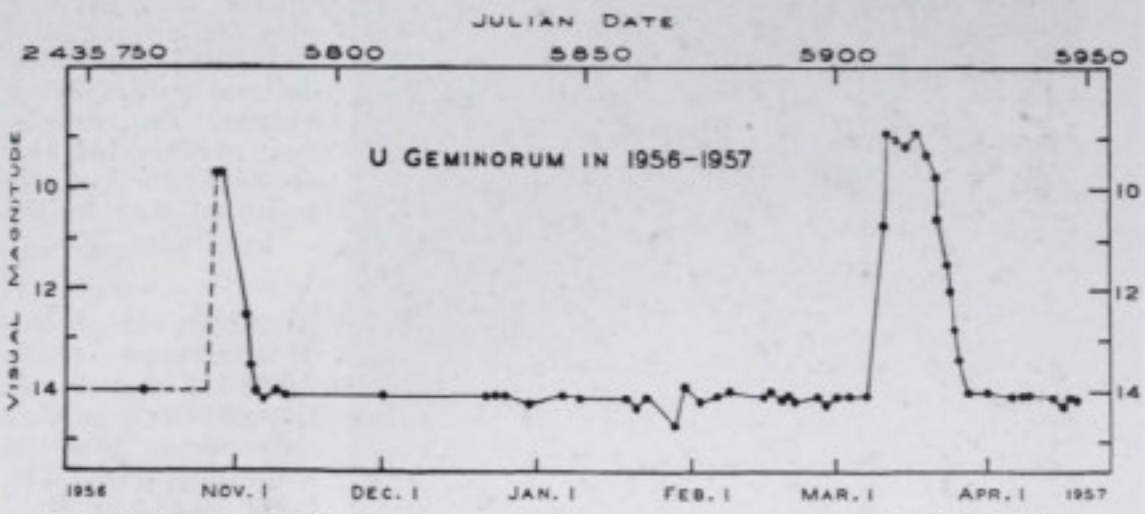
Star	R.A. h	m	Dec. °	′	Magnitude Max.	Min.
R Cor. Bor.	15	46.5	+28	18	5.8	[14
RY Sagittarii	19	13.3	−33	37	6.0	14.0
RS Telescopii	18	15.1	−46	34	8.3	[12
SU Tauri	05	46.1	+19	03	9.5	16.0

SOME U GEMINORUM VARIABLES*

SS Cygni	21	40.7	+43	21	8.2	12.1
U Geminorum	07	20.4	+13	10	8.8	13.8
RU Pegasi	22	11.5	+12	27	9.4	14.4
Z Camelopardalis	08	19.7	+73	16	10.2	13.4

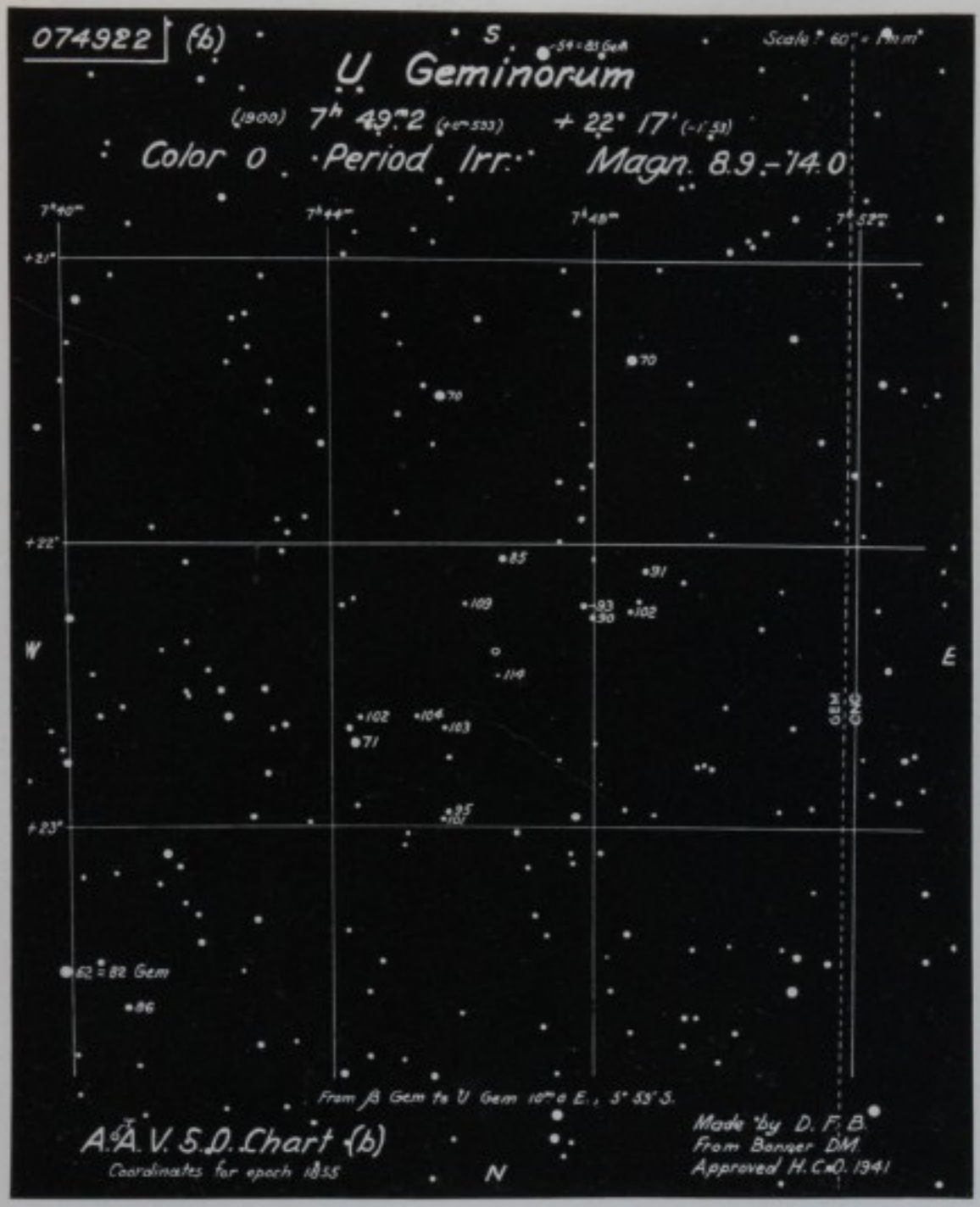
*These four stars have average cycle lengths, in days: SS Cyg, 50; U Gem, 103; RU Peg, 70; Z Cam, 20.

In this table the R.A. and Dec. are for the epoch 1950; the magnitudes are visual, the bracket indicating "fainter than." All data are from *General Catalogue of Variable Stars*, Kukarkin and Parenago, 1948.



The light curve of U Geminorum during the winter season of 1956-57, from records of the American Association of Variable Star Obsefvers.

FACING PICTURE: Here, in a single view, is a graphical record of the light variations of R Coronae Borealis over more than 170 years. The portion of the light curve from 1783 to 1923 was compiled by Harlow Shapley and the late Leon Campbell, from all published observations. The extension of the curve to 1957 is by Margaret W. Mayall, director of the American Association of Variable Star Observers. The earliest observations are by the British amateur Edward Pigott, who first suspected the variability of this star in 1783, and announced it as proven in 1797. Since 1840 the observational record is practically unbroken; in recent years the star has been under the continual scrutiny of amateur astronomers all over the world. The rare class of variable stars of which R Coronae Borealis is the prototype is characterized by long pauses at maximum light. But from 1864 to 1873, this variable showed remarkable abnormalities; faint more of the time than bright, it seemed unable to return to its normal, constant brightness. A shorter recurrence of this disturbance began about 1908.



carbon, and it is thought that this condenses into molecular form at some distance above the photosphere of such a star, forming a shield that temporarily dims its light drastically (see *Sky and Telescope*, August, 1953, page 265).

In any discussion of the U Geminorum variables and their relatives, there is a strong temptation to include the spectacular flare stars, which are of an entirely different type. A flare star is a red dwarf, usually with bright lines of calcium and hydrogen in its spectrum. When a flare occurs, the star brightens by a magnitude or so and fades again, ordinarily within a few minutes. The entire outburst and return to normal can be as short as 90 seconds, and may recur unpredictably at intervals of the order of a day.

There are two distinct types of flare. The explosion type is characterized by a sudden brightening within a few seconds, followed by a slower decline. Mound-type flares are marked by gradual brightening, generally about half a magnitude and lasting 10 minutes or more; this type seems commoner than the explosion type.

In 1952, V. Oskanjan at Belgrade observed a remarkable super-flare—UV Ceti brightened by five magnitudes in 20 seconds. The change in brightness was 100 times!

When the existence of flare stars was first recognized only a few years ago, it was thought that their behavior could be accounted for by an ordinary solar-type flare appearing on a small, dim red dwarf star. The contribution of the flare to such a star's total light would be considerable. Recent studies indicate that the picture may not be so simple, and the mechanism that produces the flares remains a mystery.

The patient observer of a flare star can expect eventually to see one of the most striking events in the heavens. But he must be content with many long waits at the telescope. The U Geminorum stars are in a somewhat similar category, as observers with small instruments can see them only after they have reached maximum. Except for a few such stars on the programs of the American Association of Variable Star Observers and the corresponding French and Scandinavian societies, they go rather poorly observed.

Though not many variables of the R Coronae Borealis type are known, they are perhaps the best candidates for systematic patrol by amateurs. Two of them —R Coronae Borealis and RY Sagittarii— are within easy reach of field glasses when at normal maximum light. Thus, the amateur with a small instrument can watch them for the first definite signs of fading, then he can alert other observers with instruments large enough to follow them part or all of the way to minimum light.

Above is the AAVSO chart (b scale) for the variable star U Geminorum, indicated by the small circle in the center square. Comparison stars are marked with their visual magnitudes, decimal points being omitted. The co-ordinate grid is for the epoch 1855, but the positional data at the top are for 1900.

At the left is a portion of the larger-scale AAVSO d chart for U Geminorum, which shows stars to as faint as magnitude 14.5. The heavy square centered on the variable is half a degree on a side.

ED. NOTE: Amateur astronomers who are interested in carrying out a systematic program of observing these and other variable stars should write to the Director, American Association of Variable Star Observers, 4 Brattle St., Cambridge 38, Mass. Blueprint charts showing the locations of the variables and their comparison stars may be purchased at cost. AAVSO observers send in their reports at the end of each calendar month, to enable up-to-date plots of the light curves to be made. International cooperation is particularly valuable in keeping track of these stars around the clock, that is, around the world; therefore, reports from readers in foreign countries are especially desirable.

Satellite Talk

EARTH'S new family of artificial moonlets was increased by two on November 3, 1957, at 4:40 Universal time, through another successful Soviet launching. Placed in an orbit somewhat larger than those of the first satellites, Satellite 1957β consisted of a third-stage rocket and a discarded nose cone. As 1957α had three parts (23-inch sphere, rocket, and nose cone), there were five small independent bodies circling the earth in November.

Orbit of Sputnik II

Early information about 1957β was summarized on page 55 of the December issue, and now may be supplemented from later reports. According to the first Russian announcements, the new satellite's period was 103.7 minutes, so it was making 14 circuits of the earth per day, instead of the 15 of 1957α.

From observations extending over about three days, George Veis, Smithsonian Institution Astrophysical Observatory, calculated the following orbital elements (see pages 66 and 67, December issue, for definitions):

The average distance, a, of the satellite from the earth's center was 1.14604 equatorial radii of the earth. Since the eccentricity, e, was 0.0965, the apogee height of the satellite was 1,017 miles above the earth's surface, and the perigee height was 140 miles. The period was 103.66 minutes on November 4th, shortening at the rate of 0.024 minute or 1.4 seconds per day.

The inclination, i, of 1957β was 63.4 degrees to the earth's equatorial plane. On November 4th, at 0:50.7 UT, the satellite passed northward through the plane, and at that time, the satellite's right ascension as seen from the center of the earth was 112°.4. This quantity, the right ascension of the ascending node, was decreasing by 3.1 degrees each day. Lastly, ω, the angle in the orbit plane between the ascending node and the perigee point, was 39 degrees.

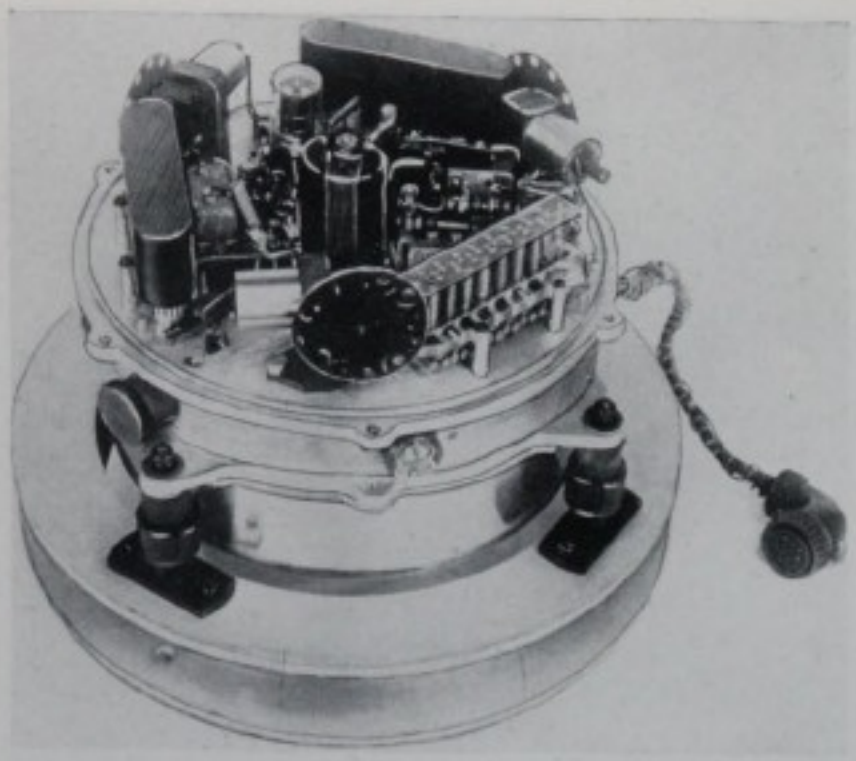
Experience with Sputnik I showed that it was far easier to track the carrier rocket (1957α1) optically than was the satellite sphere (1957α2), because the latter was several magnitudes fainter. Therefore, Sputnik II is itself the final stage of a rocket. Fixed to a special frame within it are instruments for studying solar radiation in the far ultraviolet and X-ray regions of the spectrum, a spherical container with radio transmitters and other instruments, and a hermetically sealed chamber to carry the test animal, a dog. The apparatus for cosmic ray observations was fixed to the rocket's body. Russian scientists have released details of this equipment.

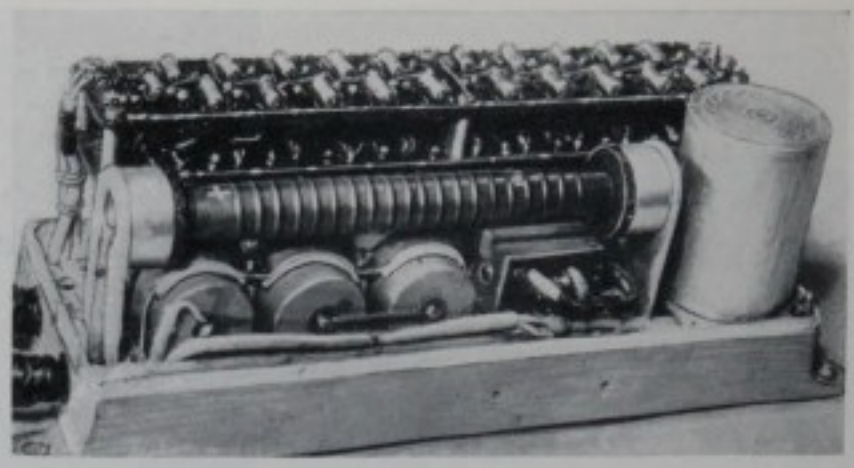
A nose cone, made of a ceramic containing cobalt, shielded the instruments from the aerodynamic heating effects of the rocket's upward passage through the dense lower layers of the atmosphere. After the final stage was placed in its orbit, the protecting cone was separated from the rocket, but continued in an orbit around the earth. The radio transmitters and equipment for telemetering observational data from Sputnik II were designed to operate for the first seven days only; since then that satellite has been tracked optically and by radar.

The second of the Soviet satellites, Sputnik II, is here photographed as it moves upward among the stars of Cancer. Beta Cancri is the star to the right of the trail's beginning, with the Beehive cluster above its middle portion. Beneath this trail is the head of Hydra. The brilliant star at the extreme right edge of the picture, below center, is Procyon. Paul Donaldson used a Rolleicord camera at f/3.5, Tri-X film, and a 15-second exposure, near his home in Arlington, Massachusetts, at 5:08 a.m. Eastern standard time, November 7, 1957.

The solar-radiation apparatus carried three photomultiplier cells, set at 120 degrees from one another, and each equipped with a filter wheel. By means of the optical filters, the Lyman-alpha line at 1216 angstroms and selected regions of the X-ray solar spectrum could be isolated, these being observed in succession as a motor turned the filter wheel. The electrical energy from the photomultiplier tube, proportional to the intensity of the sun's radiation at each of the selected wave lengths, was amplified and telemetered to monitoring stations on the ground.

Owing to the continual change in the satellite's orientation with respect to the sun, and also to the fact that part of its orbit was on the nighttime side of the earth, the electric circuits were switched on only when the sun came within the range of vision of any of the three light receptors. This was done automatically by means of photo-resistors lit by the sun at





Above: The instruments in Sputnik II for recording cosmic rays, showing a counting tube and its associated electronic parts. The rocket carried two of these tubes.

Left: The instruments in Sputnik II for observations of the ultraviolet and X-ray regions of the solar spectrum. The filter wheels are prominent in front of the three photomultiplier cells.

the same time as the photomultipliers.

In structure, the spherical container in Sputnik II resembles the 23-inch ball of Satellite 1957α2. It contains the radio transmitters, the storage batteries, the heat-regulating controls, and sensitive elements for recording temperature and other physical quantities.

The hermetically sealed chamber is cylindrical in shape. It contained air-conditioning equipment and a stock of food for the laika dog. There was equipment for recording the animal's pulse beat, breathing, and blood pressure; also, apparatus for taking electrocardiograms and measuring temperature and pressure within the chamber. The heat controls inside both the spherical and cylindrical chambers maintained a set temperature, transferring excess heat into the rocket hull by forced-gas circulation.

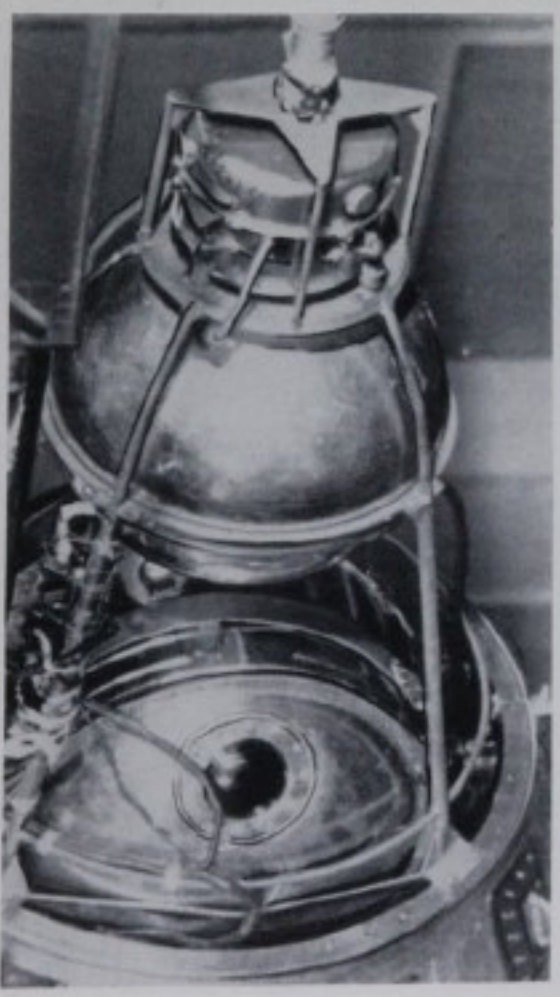
As a carrier of cosmic ray recording apparatus, an artificial satellite crossing a wide range of terrestrial latitudes has many advantages. Cosmic ray particles are strongly deflected in their passage through the earth's magnetic field; only those with very great energies pass unhampered directly to the earth's surface. Equatorial regions are reached by cosmic protons with energies of more than 14 billion electron volts, whereas at the latitude of Moscow particles of only one-tenth this energy can strike the surface.

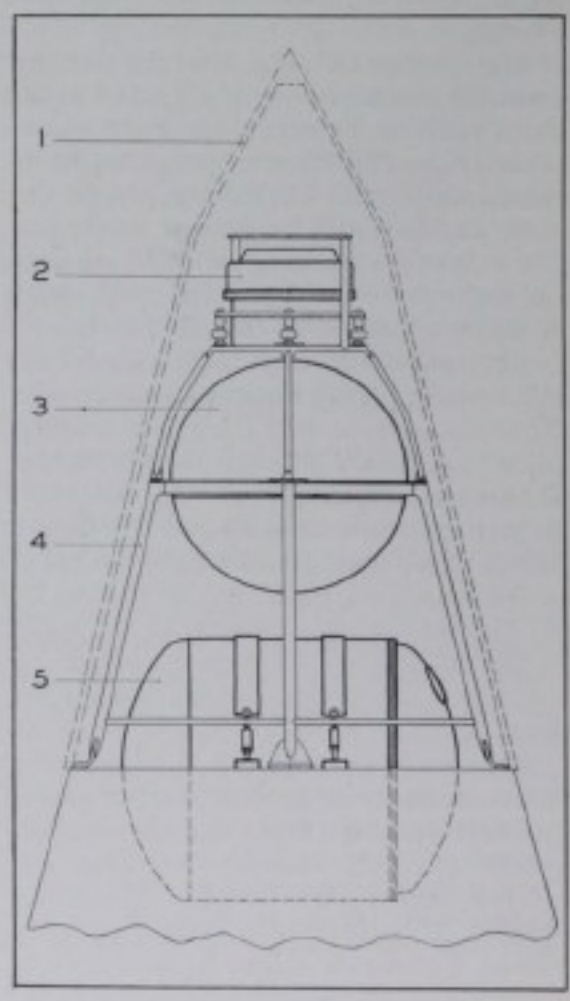
This latitude effect in the observed intensity of cosmic rays is a measure of the distribution of the incoming particles according to their initial energies – the energy spectrum of cosmic radiation. Hitherto, considerable time has been required to carry cosmic ray counting apparatus long distances north and south by means of ships or planes, and the observations have not been made within a short enough interval to be homogeneous. Moving at a speed of five miles a second, Sputnik II carried its cosmic ray counters from far southern to far northern latitudes in about half an hour, and repeated the process many times in succession, giving a great number of measurements that clearly showed the latitude effect.

This satellite carried two identical detectors for recording charged cosmic ray particles, the counter axes being perpendicular to each other. Semiconductor triodes were used to keep count of the particles triggering the detectors, and to send out a signal when a definite number of particles had been counted. Another signal was sent when the same number had been observed again. The intensity of cosmic radiation is obtained by dividing the total number of recorded particles by the time interval.

Upper-Air Densities

The cumulative effect of air resistance on the motion of an artificial satellite is to force it downward and thus to shorten its period. If the orbit is appreciably elliptical, almost all of the drag occurs





The diagram at the right indicates arrangement of equipment within the second Soviet satellite, as shown at the left. 1. A protective cone, discarded after the rocket reached its orbit. 2. Solar-radiation apparatus, seen at the top of this page. 3. A spherical capsule containing other instruments and radio transmitters. 4. The frame carrying instrumentation. 5. The chamber carrying the test animal. All illustrations on this page are courtesy U. S. S. R. Embassy, Washington, D. C.

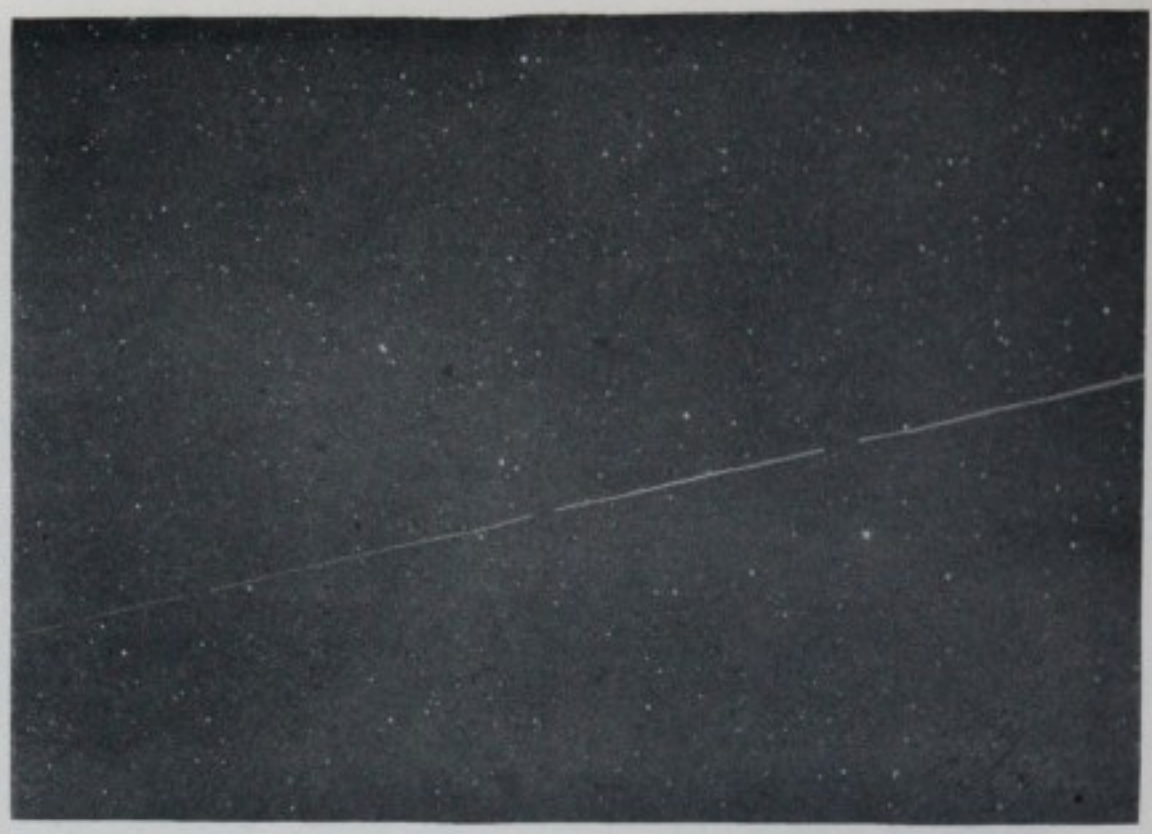
near perigee, where the atmosphere is much denser than at apogee. Hence, it is possible to deduce the air density at the perigee height, from the observed rate of shortening of the period.

The rate of decrease has been determined for three bodies: 1957α1 (the last stage from the October launching), 1957α2 (the 23-inch sphere), and 1957β. British and American scientists have already utilized these data to find that the air some 150 miles up is several times denser than had hitherto been supposed from indirect data.

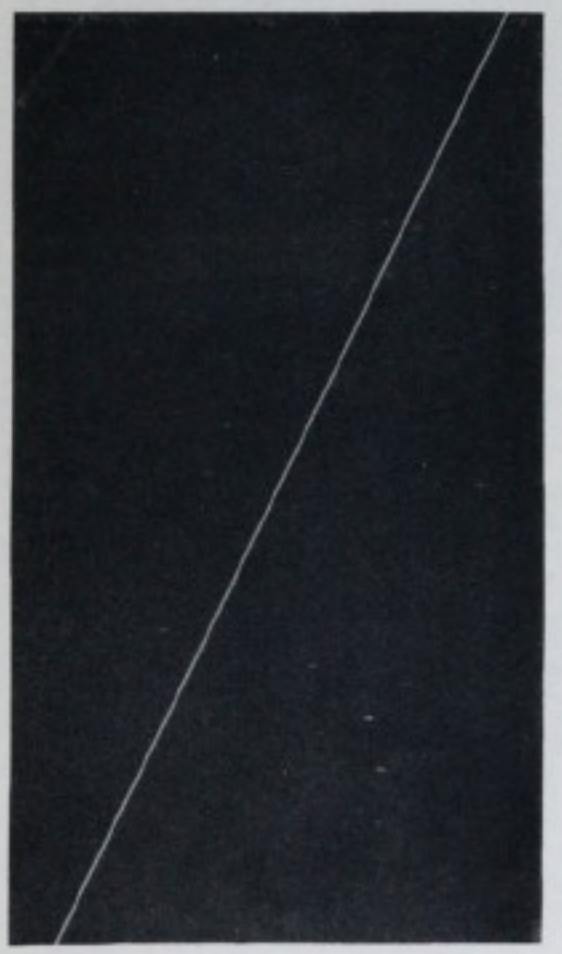
The British study was by the staff of the Mullard Radio Astronomy Observatory, Cambridge, England, and is reported in *Nature* for November 2, 1957, page 879. They adapted their radio telescope to pick up the 20- and 40-megacycle signals transmitted from 1957α2, and by repeated observations were able to determine the orbit of this body, ascertaining that its revolution period was decreasing by 2.2 ± 0.1 seconds each day by October 15th. (The decrease becomes faster and faster as the orbit shrinks. Russian data for November 10th indicated that the carrier rocket's period was then some 74 seconds less than the sphere's.)

On the assumption that the air particles adhere temporarily to the surface of the satellite and then leave with thermal velocities, the Cambridge scientists deduced that the rate of period change would be accounted for if the 23-inch, 184-pound sphere encountered 1.8 grams of air during each trip around the earth. Assuming an absolute temperature of 1,000° Kelvin, this would mean that the atmospheric density 125 miles above the ground was about 4×10^{-13} grams per cubic centimeter.

The American investigation was carried out co-operatively by the Smithsonian Astrophysical Observatory and the Naval Research Laboratory, using hundreds of visual, photographic, and radio observations of Soviet satellites and the carrier rocket of Sputnik I. The preliminary results indicate an air density, at an altitude of some 140 miles, about five times the expected value of 10^{-13} grams per cubic centimeter. This agrees well with the British finding.



For this picture of the passage of Sputnik II on the morning of November 6th, Robert Gliebe covered the camera lens with a cardboard at times which he recorded by simultaneously depressing the key of a chronograph. In Pacific standard times, the breaks (from right to left) occurred at: 1st, not timed; 2nd, 5:27:56; 3rd, 5:28:01; 4th, 5:28:03. The location was Fair Oaks, California, at an elevation of 180 feet above sea level, longitude 121° 16′.6 west, latitude 38° 38′.4 north. The Sickle in Leo lies inclined in the upper center of the field, with Regulus the bright star to the right and below the satellite.



From a point 7.7 miles north of the MOONWATCH station at Downers Grove, Illinois, station leader William B. Doe photographed the second Russian satellite on November 6th. The rocket passed near Gamma Camelopardalis, which is the brightest star in the picture. The lower border of the reproduction is at declination about +69°, and the upper border at about +77°. The satellite was photographed simultaneously from the MOONWATCH station itself.

A Correction

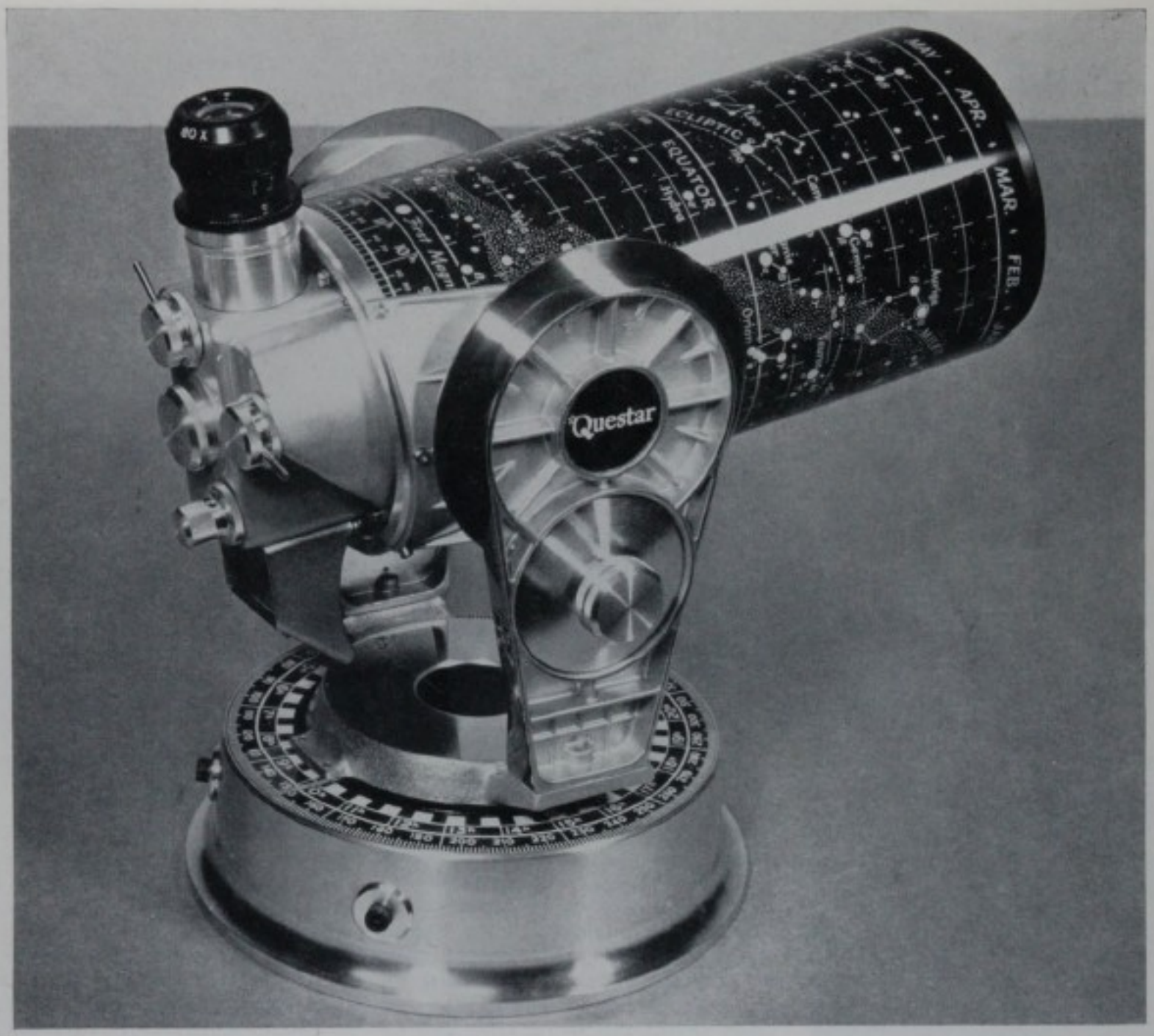
On page 58 of the December issue a statement is repeated from the Soviet press to the effect that the angle of crossing the earth's equator by the first satellite differs markedly from the 65-degree inclination of the plane of the orbit. The ascending node passage was said to be at 71½ degrees, the descending at 59 degrees. Dr. John S. Rinehart, assistant director, Smithsonian Astrophysical Observatory, points out that for Satellite 1957α1 the angle of crossings of the equator is approximately 68 degrees in both directions. He writes, "If, as viewed by an observer in space, the orbital plane of a satellite is inclined at an angle with respect to the equatorial plane of the earth, then an observer stationed on the earth does not see the satellite cross the equator at this angle, because he is moving with the earth. The two situations of passage, from the Southern Hemisphere into the Northern Hemisphere, and vice versa, are basically the same. For an elliptical orbit, however, the two angles may differ slightly, depending upon the positions of apogee and perigee."

Fate of 1957α1

The third-stage rocket of Sputnik I is believed to have fallen to earth shortly after the last known radar contact was made at 00:12 Universal time on December 1, 1957, by the Stanford Research Institute, Palo Alto, California. At that time the rocket's height was 107 miles.

Air drag on the rocket shell had reduced its orbital period to 88 minutes—nearly 10 minutes less than initially, almost 900 revolutions earlier. But now the mounting effects of air resistance were forcing it down with increasing rapidity.

After the Stanford observation, British radio astronomers at Jodrell Bank failed to establish radar contact during seven possible passages of the satellite on December 1st. As this issue goes to press, there is no definitely confirmed report of the rocket's fall having been seen. This would have been a conspicuous phenomenon, resembling a great fireball if the descent took place on the night hemisphere of the earth.



QUESTAR GUARANTEES 0.9-SEC. RESOLUTION

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If telescopes are guaranteed at all, as they ought to be, they are usually guaranteed to equal their theoretical resolving power. For Questar's 3½-inch aperture the Dawes limit is 1.3 seconds of arc. Since nature seems to favor small apertures of some 3 to 5 inches, a telescope in this size range is poor indeed if it cannot meet its theoretical limit of resolution. It therefore seems to us that such a guarantee means little. Further, it puts the burden of proof entirely on the purchaser.

Absolutely tremorless and quiet air is essential to the testing of a telescope if you really want to know how well it will perform. When an instrument is tested on the night sky, the rays of light that reach it must traverse the earth's entire atmosphere. The least movement in the disc and ring system of a star image is evidence of atmospheric interference, as W. H. Pickering has pointed out. Bell tells of a famous English astronomer who "had seen but one first-class night in 15 years." One Questar owner observed for two years before a night of exceptionally fine seeing revealed his instrument's full capabilities. This all sounds discouraging, but we are speaking of not just good seeing, but of seeing that is perfect.

We can make our own perfect seeing by drastically shortening the air path through which we look to read the proper test chart, and this will demonstrate precisely the resolving power of a telescope in seconds of arc. The charts we use are purchased from the Bureau of Standards. They may be used outdoors in the quiet air of early morning or late afternoon at distances up to 300 feet, or even indoors at only 41 feet.

Here is a method of testing telescopes on which we can base a performance guarantee and at the same time furnish the simple means to prove it. We do not ask the novice to familiarize himself with star or planetary test objects, and then wait weeks or months for steady air to look through. The man who buys a Questar now may have room to test it indoors the very day it arrives, regardless of the wind or rain or cold of outside weather. He can duplicate our test himself; the chart will tell him at a glance whether his 3½-inch Questar resolves the 0.9 second of arc that we guarantee.

In going to the chart system, we only do what the Air Force and other photographic people have been doing for years. They have to know the exact quality of some very large and costly lens systems, and various kinds of charts and patterns for this purpose are in common use.

In consulting the experts at the Bureau of Standards on our special needs, they suggested that we use a chart which they make photographically on glossy paper, the smallest lines of which cannot be seen with the naked eye. The Bureau's recommendations for its proper use are embodied in the directions which we send with every chart.

The De Luxe Questar sells complete with all accessories at $995. The Field Model at $495 consists of the same major optics in a simple barrel without built-in auxiliary devices, with bracket casting for mounting on a panhead tripod, 40x eyepiece and choice of star diagonal or erecting prism. This model will accept 1¼-inch standard eyepieces.

QUESTAR CORPORATION
New Hope, Pennsylvania

These five exposures of the partially eclipsed moon were taken by Frederick A. Eiserling at Palos Verdes, California. The images are at four-minute intervals beginning at 5:28 a.m. Pacific standard time, using a 5-by-7 view camera at f/5.8. The exposures were ¾ second on Royal Pan film.

was the scene for a nationally televised coverage of the eclipse. The National Broadcasting Company showed the pictures over its morning program, "Today," and many observers on the East Coast watched the eclipse in the comfort of their living rooms. Tom Quinn, who went to the observatory with his father, reported that about a dozen television cameras were set up. He photographed the moon until 6:10 a.m., when the eclipse was not quite total.

The moon was high in the sky at Honolulu, Hawaii, where Robert Hancock observed with a 2.4-inch refractor, 40x, until clouds intervened just after totality began. When the moon was three-quarters covered, the eclipsed portion appeared yellow-orange, and he could just make out Tycho inside the umbra.

At Yokosuka, Japan, L. B. Mitchell, of the USS *Dixie*, photographed the moon with a 3-inch f/15 refractor that he had built. Five pictures were secured, the first (reproduced below) at 9:45 p.m. Japanese standard time. A light ground fog prevented observations of the closing stages of the eclipse.

The umbra, or dense inner shadow of the earth, had already covered the eastern edge of the moon by the time this photograph was taken by L. B. Mitchell, U. S. Navy, at Yokosuka, near Tokyo, Japan.

A BRIGHT RED AURORA

A SPECTACULAR cherry-red display of northern lights on November 6, 1957, was by far the most beautiful witnessed during the month. The aurora was seen as far south as Virginia.

Traces of a patchy aurora were first spotted by Joseph Conte, of Bayside, New York, at about 8:15 p.m. Eastern standard time. By 8:20 the color was a deep red, extending up to the zenith and into Pegasus. The full moon seemed to have little effect on the display. At 8:25 Mr. Conte noted a blue-white spot between Cygnus and Draco, in the heart of the surrounding red color. At the same time, the glow extended through and above Auriga in the east.

The display was conspicuous from New Jersey. In the bulletin of the Bergen County Astronomical Society, Peter Zimmer noted that the display began with two large hazy patches, one in the northeast and the other in the northwest. The first faded rapidly while the other grew in brightness and size, forming a boot-shaped pattern, with a bright streak running at an acute angle to the horizon.

At Middleburg, Virginia, Duncan H. Read reported that the display extended from the horizon up about 35 degrees. He described the color as cherry red, many times more intense than any auroral color he has seen in the past, "with no yellow or orange tint such as a local fire might develop."

Walter A. Feibelman, Pittsburgh, Pennsylvania, timed the display as lasting from about 8:15 to 8:45. He obtained both

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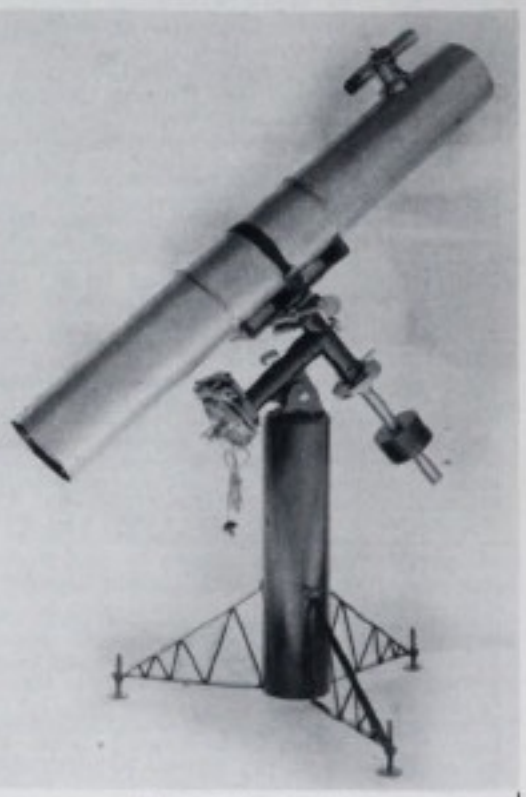

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black-and-white and color photographs of this aurora.

In Springfield, Massachusetts, Robert M. Ayers, Joseph Canter, and Richard Orenstein saw the aurora start about 8:15. Beginning as a reddish glow in the northern sky, it soon developed into a distinct red patch in the northwest. Next green rays appeared, converging toward the zenith, and soon the glow changed into a red-and-green mottled smudge. A green homogeneous arc was then seen, and afterward the display faded, disappearing completely by 8:35.

At Cambridge, Massachusetts, the red aurora covered the whole northern part of the sky, and it extended past the zenith to the south. Maximum intensity occurred about 8:30 p.m. Rays were seen in the northeast, and patches in the northwest, the zenith, and the east.

NAKED-EYE SUNSPOT OBSERVING

With solar activity now at a high level, sunspots large enough to be seen without telescopic aid should be fairly frequent. To observe when the sun is far above the horizon, use a regular eyepiece sun filter, or several thicknesses of overexposed film negatives, although the flexible film may introduce some distortion. When the sun is near the horizon or behind mist, less protection is needed. In any case, the observer should be careful to avoid damage to his eyes.

As an example of unaided-eye observations, I saw two sunspot groups about noon on May 12, 1957, using an eyepiece sun filter. One group was quite conspicuous, the other rather difficult.

GUS JOHNSON
934 Pine Ave.
Pittsburgh 34, Pa.

SUNSPOT NUMBERS

These are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

October 1, 244; **2**, 240; **3**, 249; **4**, 233; **5**, 230; **6**, 239; **7**, 224; **8**, 250; **9**, 274; **10**, 270; **11**, 220; **12**, 260; **13**, 246; **14**, 258; **15**, 250; **16**, 289; **17**, 268; **18**, 228; **19**, 223; **20**, 235; **21**, 250; **22**, 255; **23**, 260; **24**, 285; **25**, 247; **26**, 310; **27**, 286; **28**, 340; **29**, 350; **30**, 330; **31**, 306. Mean for October, 262.9.

M. Waldmeier has supplied the following predictions for the smoothed monthly sunspot numbers: January, 164; February, 160; March, 156; and April, 152.

Zurich provisional sunspot numbers are transmitted by the Swiss Broadcasting Corporation by short wave on the 4th and 5th of the following month. Listeners in North America can hear these reports on the 5th of each month at 01:35 UT on wave lengths of 48.66, 31.46, 31.04, and 25.28 meters, and at 04:20 UT on 31.46, 31.04, and 25.28 meters. Reports beamed to South America at 23:30 UT on the 4th are on 31.46, 25.28, and 19.60 meters; and at 03:45 UT on the 5th on 31.46 and 25.28 meters. This schedule will be used through April 5, 1958.

The following American sunspot numbers for October were derived by Dr. Sarah J. Hill, of Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

October 1, 219; **2**, 245; **3**, 225; **4**, 223; **5**, 221; **6**, 196; **7**, 226; **8**, 257; **9**, 216; **10**, 201; **11**, 219; **12**, 245; **13**, 245; **14**, 190; **15**, 207; **16**, 212; **17**, 186; **18**, 161; **19**, 191; **20**, 194; **21**, 203; **22**, 228; **23**, 223; **24**, 263; **25**, 259; **26**, 265; **27**, 277; **28**, 276; **29**, 283; **30**, 317; **31**, 234. Mean for October, 229.2.

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FOR SALE: Tinsley Laboratories' Saturn 3" refractor, 200x, 100x, 50x, star diagonal, altazimuth mount, oak tripod, $200.00. J. L. Jones, 9700 Hilliard Rd., Pittsburgh 37, Pa.

WANTED: 5" achromatic objective of finest quality and condition. Prefer Zeiss. F. Buch, Alpes 324 Lomas, Mexico D. F., Mexico.

TELESCOPES: 8-power M-17 elbow telescopes, as described optically in April, 1957, issue, page 292. Government cost $175.00, optically perfect, equipped with threaded standard tripod adapter, also usable for telephoto photography. Satisfaction guaranteed or money refunded. Price, $14.85 postpaid. Shelsy and Co., 250 W. Broadway, New York 13, N. Y.

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A VIEW OF THE LUNAR CRATER KIES

In recent years, amateur observers of the moon have been paying increasing attention to lunar domes, small rounded hills that are being discovered in considerable numbers.

Here is a sketch of the walled plain Kies, made with a 10-inch Newtonian reflector on October 6, 1954, between 18^h and 19^h Universal time, when the moon was 1½ days past first quarter.

The crater Kies, sketched by A. C. Larrieu, is about 27 miles in diameter.

Lit by the rising sun, the eastern wall of Kies casts a long shadow reaching out to one of the best known of lunar domes. This beautiful example has the small depression in its top common in these objects.

I find this region of the moon very interesting to observe, where the plains of the Mare Nubium meet the highlands bordering it to the east.

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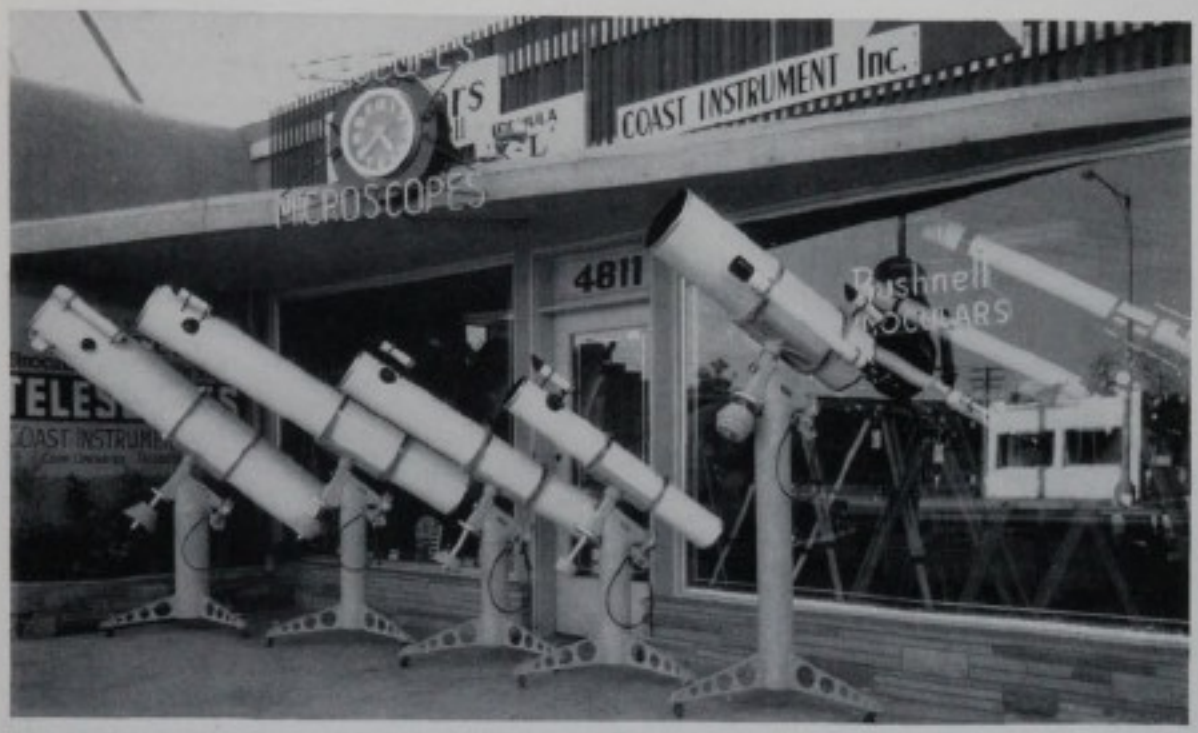

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BOOKS AND THE SKY

THE AMATEUR ASTRONOMER

Patrick Moore. W. W. Norton and Co., New York, 1957. 337 pages. $4.50.

PATRICK MOORE is probably the most prolific author of popular astronomy books who is at work today. His latest contribution is designed for the beginner with a small telescope. Mr. Moore is a well-known observer himself, and certainly qualified to introduce the novice to the fascinations of astronomical observations.

The style is flowing and the book reads easily. After a brief historical account, there is a systematic description of the solar system. The last quarter of the book is devoted to stars, clusters, nebulae, and galaxies. This is followed by a group of photographs and 29 valuable appendices, which include an extensive list of proper names of stars, a catalogue of standard stars for each magnitude, a listing of pairs of stars for angular measure, a table of the limiting lunar detail visible with different apertures, a bibliography, and star charts.

The author's sympathies obviously lie with the solar system, a preference shared by most amateurs. "There is little point in exploring the heights of Everest if we still lack a thorough knowledge of Long Island," he writes, although by this argument there would be little point in observing the moon until the Himalayas have been fully charted. The British astronomer waxes most enthusiastic in describing lunar studies. While these are among the most interesting amateur observations, this reviewer believes that most professional astronomers would doubt that by their drawings "amateurs can play a major role in helping to clear up" modern lunar problems.

An interesting fact brought out by Mr. Moore is that Pluto has brightened sufficiently since its discovery to be visible now in an 8-inch telescope. It is doubtful that many amateurs have made this observation, or have seen two of Uranus' satellites, Titania and Oberon, which are also possible with an 8-inch, according to the author.

Mr. Moore takes it upon himself to adopt the names Hestia, Hera, Poseidon, Hades, Demeter, Pan, and Adrastea for Jupiter's outer satellites. Since numbering the satellites is adequate for most astronomical purposes, the indifference of astronomers must account for the lack of names. Perhaps these very names will ultimately come into use.

The American Association of Variable Star Observers receives a brief two-line mention in an appendix of this book. Nothing is said of its solar division, and no indication is given in the chapter on the sun that regular sunspot counts are of value and should be reported. This is especially surprising, since the book was obviously written for American as well as English readers.

There appear to be only a few errors, typographical and otherwise, scattered through the book. The photograph of M51 is identified as M81, and both *W* and *O* spectral types are included as Wolf-Rayet stars. The expression "galactic spectra" occurs where "spectra of galaxies" is meant. The old explanation of the formation of comet tails by light pressure is presented, although recent work by L. Biermann shows that corpuscular radiation must be the principal agent of this phenomenon. Similarly, little distinction between meteors and meteorites is given, although the contrasts in their characteristics are now known to be very great.

Unfortunately, the Messier catalogue in appendix XXVI lists M47, M48, and M102, which are nonexistent objects; the accompanying statement that M40 may have been a comet is entirely false.

Altogether *The Amateur Astronomer* is useful and admirably suited to a serious beginner.

OWEN GINGERICH
American University Observatory
Beirut, Lebanon

INTRODUCING ASTRONOMY

J. B. Sidgwick. The Macmillan Company, New York, 1957. 259 pages. $3.50.

IT IS OFTEN imagined that without expensive equipment and a long technical training the pursuit of astronomy must be a waste of time and the night skies a closed book. Nothing, says the author of this book, could be further from the truth. He emphasizes that anyone can enjoy astronomy, and remarks that the first view with binoculars of the crescent moon, or the Milky Way, or the Double Cluster in Perseus, is a revelation.

Mr. Sidgwick relates how amateurs, many beginning with the most modest of instruments, have attained distinguished positions in the history of astronomy; and he recounts the achievements of a few whose names are well known in the field.

Introducing Astronomy, in which the author assumes no previous knowledge of the subject, is an excellent key to the fundamental concepts of the heavens. This introduction is popular but not too superficial. For instance, Mr. Sidgwick describes both the method for determining the distance of a star from the parallactic shift, and how the distance may be found from the star's luminosity.

The book is divided into two sections: Part I is a rapid survey of the astronomer's domain, from the solar system to the stars and on to the remote galaxies. Part II contains data for the observer.

The reviewer is amazed at the vast amount of material included in the 118 pages of Part I, and finds the author quite

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adept at giving the beginner a clear and intelligible description of astronomical objects and modern interpretations. He also offers some insight into the methods by which much information has been obtained. Adequate descriptions are given of instruments, telescopes, spectroscopes, the Schmidt camera, and the radio telescope.

To the seasoned astronomer, the first chapter, "Why Study Astronomy?" makes rather dull and tiresome reading toward the end, in its minute details as to magnification of field glasses, how to dress and keep warm on cold nights, and how to hold binoculars steady. The second chapter, on the amateur's first night out, contains valuable information for understanding the celestial sphere and how the heavenly bodies appear to move. There is too much repetition and summarizing, however, for pleasant reading. The chapters that follow discuss the sun, members of the solar system, the stars, the Milky Way, star clusters and nebulae, and astronomical instruments. The order might be rearranged to advantage; for instance, instruments may well have come earlier in the discussion.

In general the material appears up to date, but there are a few errors. References are consistently made to the 11 moons of Jupiter instead of the 12 now known, although the five satellites of Uranus and the two of Neptune are given correctly. In the discussion of Mars, the reader is left with the impression of a higher water vapor and oxygen content than are usually accepted. The author concludes, "*If* there is life resembling the terrestrial form in its fundamental features anywhere in the Solar System besides this planet, then Mars (with its near-terrestrial conditions) is the place where we must look for it." The reviewer feels that the whole discussion concerning Mars may be slightly too strong on the evidence of life. The author is mistaken in saying that the spherical and elliptical galaxies are gaseous like galactic nebulae; they are actually composed of stars.

In chapter 3, "The Sun," the photograph of the spiral galaxy M33, on the back of a picture of the sun and spectroheliograms, appears out of place and would have been better in chapter 8. These photographs and the frontispiece of the moon are the only ones in the entire book.

The fourth chapter contains an excellent diagram of an outer planet's retrograde motion. The chapter on the moon has a detailed lunar map oriented for observation with the naked eye or binoculars, with descriptions and positions of the seas and 48 craters. This will aid a novice starting to study the moon.

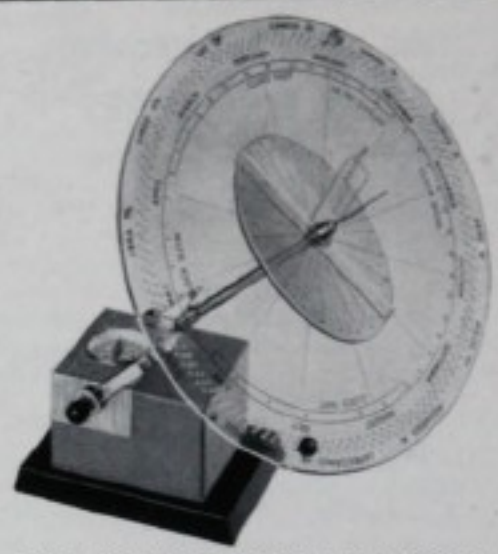
Part II consists of three appendices: a rather complete summary of data relating to the sun, moon, and planets; a description of the ways to determine time and direction by the stars, including eight methods of finding the cardinal points; and maps and descriptions of 51 constellations, with accounts of their history and mythology. For each constellation there are details about objects of interest visible with the naked eye, binoculars, or small telescopes. For the beginner in observing, there is little information lacking in this most complete and helpful appendix. A glossary of astronomical terms and abbreviations concludes the book.

In reading *Introducing Astronomy*, one must constantly bear in mind that it was designed not as a university text but as a kind of handbook or manual for amateurs. It suggests that the best way to learn and enjoy astronomy is by consistent and regular observing for one's self, not by merely reading. On the whole, the book is adequately designed for the beginner, for the many who love to look up at the heavens but have no more powerful optical aid than binoculars or small telescopes.

Mr. Sidgwick is to be congratulated on imparting much astronomical information and so many facts in a few pages. He has in recent years contributed materially through his writings and translations to the general reader and the amateur astronomer.

Introducing Astronomy can be supported with confidence.

HAZEL MARIE LOSH
University of Michigan Observatory



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ROCKETS, MISSILES, AND SPACE TRAVEL

Willy Ley. The Viking Press, New York, 1957. 528 pages. $6.75.

IN 1944 a slender volume, *Rockets*, was written by Willy Ley. It has now reached its seventh edition, revised and enlarged, more and more material having been added, especially in recent years concerning American guided missiles. This reviewer, who has read three of the previous versions, finds Mr. Ley very conscientious in keeping his major literary work up to date. It is heartily recommended.

The subject falls naturally into four main sections: history, rocket theory, practical applications, and possible applications. As an organizer of the famous German *VfR*, the Society for Spaceflight, the author is a justly noted expert on the early days of rocketry. In four chapters he describes the ancient foundations of the science and their extension by the experimental work of the *VfR*. The fifth chapter is mainly devoted to theory, although this subject turns up elsewhere in the book.

Applications of a practical nature concern the next four chapters, with emphasis on the V-2 rocket work at Peenemünde in Germany and guided-missile work at White Sands Proving Ground. The final three chapters concern artificial satellites and possible kinds of spaceships.

"The Shot Around the World" is out of date only in that it considers artificial satellites a possibility instead of the reality that they are today. But the discussion of getting satellites into their orbits, and of why they stay up, is still good and very readable.

The main body of the text occupies 399 pages; the other 129 are devoted to appendices and the index. Detailed descriptions are included of rocket airplanes and missile characteristics and firings. A bibliography of books and articles in English, French, German, Russian, and five other languages rounds out the book and increases its value as a reference.

W. E. S.

NEW BOOKS RECEIVED

THE OBSERVER'S HANDBOOK 1958, *Ruth J. Northcott*, editor, 1957, *Royal Astronomical Society of Canada*, 252 College St., Toronto 2B, Ontario. 84 pages. 75 cents, paper bound.

Now in its 50th year, this valuable aid to the amateur astronomer gives in easy-to-use form data for 1958 on the sun, moon, planets, Jupiter's satellites, and meteor showers. There are also variable star predictions, as well as listings of rising and setting times of the sun and moon especially adapted for observers in the United States and Canada. Other tables give facts on double stars, clusters, nebulae, and galaxies suitable for observing with amateur telescopes.

A particularly useful feature is a catalogue of the 286 stars brighter than magnitude 3.55, with colors, motions, distances, and absolute magnitudes. A supplement gives the visiting hours at some Canadian observatories.

AUFBAU UND ENTWICKLUNG DER STERNE, *Heinrich Vogt*, 1957, *Akademische Verlagsgesellschaft*, Sternwartenstrasse 8, Leipzig C1, East Germany. 171 pages. DM 16.

Structure and Evolution of the Stars is the second and revised edition of a work that originally appeared in 1943, by a leading German astrophysicist. It is a concise theoretical treatment of such topics as energy generation and transport inside stars, stellar models, stability, and rotation. Mathematical in character, this book is primarily for professional astronomers and advanced students who read German.

RECEIVING AERIAL SYSTEMS, *I. A. Davidson*, 1957, *Philosophical Library*. 152 pages. $4.75.

Though primarily discussing radio and television antennas, *Receiving Aerial Systems* will be of interest to any amateur concerned with receiving time signals or building a radio telescope. The mathematics for determining antenna characteristics and performance is briefly outlined, and information is given about radio-frequency cables to carry the signal from the antenna to the receiver — a subject of great importance that is usually neglected.

APPARENT PLACES OF FUNDAMENTAL STARS 1958, 1957, *Her Majesty's Stationery Office*, York House, Kingsway, London W. C. 2, England. 536 pages. £2 2s.

Apparent positions of bright stars, no longer included in the *American Ephemeris*, continue to be carried in this annual volume produced under the auspices of the International Astronomical Union. Right ascensions for 1,535 stars are given to 0.001 second and declinations to 0".01, at 10-day intervals. In the United States, this book can be ordered for $7.82, postpaid, from the British Information Services, 45 Rockefeller Plaza, New York 20, N. Y.

THE INNER METAGALAXY, *Harlow Shapley*, 1957, *Yale University Press*. 204 pages. $6.75.

The former director of Harvard Observatory discusses the results of his extensive investigations of galaxies during the past 30 years, dealing with the Clouds of Magellan, the north and south galactic polar zones, the canopy, and the Milky Way.

LIVES IN SCIENCE, edited by *Scientific American*, 1957, *Simon and Schuster*. 274 pages. $1.45, paper bound.

Continuing *Scientific American's* collection of its magazine articles into books integrated around specific themes, these biographies trace the lives and contributions of 18 scientists, including Galileo, Newton, and Laplace.

THE AMERICAN EPHEMERIS AND NAUTICAL ALMANAC FOR THE YEAR 1959, *Nautical Almanac Office*, U. S. Naval Observatory, 1957, *U. S. Government Printing Office*, Washington 25, D. C. 589 pages. $4.25.

The character and arrangement of the newest *American Ephemeris* are the same as in the previous annual volume. Included are precise ephemerides for the sun, moon, the planets from Mercury through Pluto, and the first four asteroids. There are extensive predictions for eclipses and occultations, and for satellites of other planets. Much other material is useful to astronomers and computers. The physical ephemerides for the moon and planets are indispensable to amateurs who study these objects in detail.

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The buy of a lifetime at a great saving. Perfect war-surplus lenses set in black anodized standard aluminum 1¼" O.D. mounts.

F.L.	TYPE	PRICE
12.5 mm (½")	Symmetrical	$ 6.00
16 mm (⅝")	Erfle (wide angle)	12.50
16 mm (⅝")	Triplet	12.50
18 mm (¾")	Symmetrical	6.00
22 mm (27/32")	Kellner	6.00
32 mm (1¼")	Orthoscopic	12.50
35 mm (1⅜")	Symmetrical	8.00
55 mm (2-3/16")	Kellner	6.00
56 mm (2¼")	Symmetrical	6.00

COATED 75 cents extra.

ASTRONOMICAL MIRRORS

These mirrors are of the highest quality, polished to ¼-wave accuracy. They are aluminized, and have a silicon monoxide protective coating. You will be pleased with their performance.

	Diam.	F.L.	Postpaid
Plate Glass	3-3/16"	42"	$ 9.75
Pyrex	4¼"	45"	13.50
Pyrex	6"	60"	25.00

MIRROR MOUNT

Cast aluminum. Holds all our mirrors firmly with metal clips. Completely adjustable. Assembled, ready to use.

3-3/16"	Mount fits our 4½"	tubing	$4.00 ppd.
4¼"	Mount fits our 5"	tubing	4.00 ppd.
6"	Mount fits our 7"	tubing	7.00 ppd.

Aluminum Telescope Tubing

O.D.	I.D.	Price Per Ft.
2¼"	2⅛"	$1.20 ppd.
3⅜"	3¼"	1.75 ppd.
4½"	4⅜"	2.75 ppd.
5"	4⅞"	2.75 ppd.
7"	6⅞"	3.00 f.o.b.

Focusing Eyepiece Mounts Rack & Pinion Type

The aluminum body casting is finished in black crackle paint and is machined to fit all our aluminum tubing. Has a chrome-plated brass focusing tube, which accommodates standard 1¼" eyepieces.

For 2⅛" I.D. Tubing	Postpaid	$12.95
For 3¼" I.D. Tubing	"	12.95
For 4⅜" I.D. Tubing	"	12.95

REFLECTOR TYPE FOR ALL SIZE TUBING:
Complete with diagonal holder ..... $ 9.95

Aluminum Lens Cells

Black Anodized

Cell for Lenses	Cell Fits Tubing	Price
54 mm Diam.	2⅛" I.D.	$ 3.50
78 mm "	3¼" "	6.50
81 mm "	3¼" "	6.50
83 mm "	3¼" "	6.50
110 mm "	4⅜" "	10.50

3X TELESCOPE

Makes a nice low-priced finder. Brand new; has 1" Achromatic Objective, Amici Prism Erecting System, 1⅜" Achromatic Eye and Field Lens. Small, compact, wt. 2 lbs.

Gov't. cost $200. **$9.75**

FIRST SURFACE MIRRORS

Size	Postpaid	Size	Postpaid
14" x 16"	$10.00	5¼" x 7¼"	$3.00
10" x 10"	5.00	5" x 5"	2.00
9" x 11-3/16"	5.00	4" x 5"	1.85
8" x 10"	4.25	4" x 4"	1.50

All mirrors are ¼" thick.

TELEVISION PROJECTION LENS

Brand New, f/1.9, E.F.L. 5 inches. Manufactured by Bausch & Lomb. We purchased entire lot of these discontinued units. Five elements, smallest lens 2", largest 4⅛". Completely assembled 6" in length. All surfaces hard coated. Get this BARGAIN now.

ONLY $22.50

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WAR-SURPLUS
"SATELLITER" MOUNT

We have just discovered a radar tube mount (Gov't. cost about $50.00) that is very much like our mount for the regular MOONWATCH telescope. We include a spacer so that our $9.95 "Satelliter" telescope will fit the tube. You can attach a mirror on the end or purchase the model to which we have attached a 2" x 3" first-surface mirror with a metal bracket. The scope holder is mounted on a removable 4"-long T-slot slide, and the adjustable base has one 12" long.

The pivot point of the mirror holder will be about 1¾" below the optical axis of the mirror. This does not allow its easy use at an official MOONWATCH station. However, it is a minor point for other groups or for satellite viewing by an individual.

Adjustable through about 75° angle. Tube has spring-shock mounting. Also can be mounted and used vertically. Made of light-weight aluminum and magnesium.

Stock #70,151-Y....Mount only.....$6.00 ppd.
Stock #70,152-Y....Mount with mirror and bracket (as illustrated).....$9.00 ppd.
Stock #70,153-Y....Complete with mirror and $9.95 "Satelliter" telescope.....$18.95 ppd.

SETTING-CIRCLE SET

Two 8"-diameter dials accurately printed on 1/16"-thick black plastic, rigid but unbreakable. White figures and black background. Alternate black-and-white blocks designate divisions, allow easier reading, less eyestrain. ¼" pilot hole in center.

Declination circle has 360° divided into 1° blocks, and reads from 0 to 90 to 0 to 90 to 0.

Right-ascension circle has 24-hour scale divided into 5-minute blocks with two different scales on the same side. One reads from 0 to 6 to 0 to 6 to 0 hours and the other 0 to 24 hours consecutively. Instruction sheet included.

Stock #50,133-Y.....$5.00 ppd.

3" ASTRONOMICAL REFLECTOR

60- to 120-Power — An Unusual Buy!

Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with lock on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60X eyepiece and a mounted Barlow lens, giving you 60 to 120 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272-page ASTRONOMY BOOK.

Stock #85,050-Y.....$29.50 f.o.b.
(Shipping wt. 10 lbs.) Barrington, N. J.

4" REFRACTING TELESCOPE
240-POWER

Complete with Finder, Equatorial Mounting, Tripod, Eyepiece Extension, Star Diagonal, and Three Eyepieces

A fine instrument, designed for rugged use and quality performance. Mounting made from heavy iron castings with machined bearings for smooth operation. Tripod has extra-heavy 60" hardwood legs. Telescope's weight is 42 lbs., giving stable, steady viewing. Big 4" objective is an air-spaced achromat, each element coated on both sides for low reflection. Three eyepieces supplied give you 48X, 120X, and 240X. Special Barlow lens also gives up to 500X. Star diagonal included for comfortable viewing at high angles. Rack-and-pinion focusing. All metal parts are plated to prevent rusting. Finder is 8 power. The usual price for a 4" refractor of comparable quality is over $400, so our model saves you almost 40%.

Stock #85,038-Y.....$247.00 f.o.b.
(Shipping wt. 55 lbs.) Barrington, N. J.

100X REFRACTING ASTRONOMICAL TELESCOPE

42-mm. Diam. Achromatic Objective

Only $19.95 ppd.

Here is a nice refractor for the beginner. Has a fine, 42-mm.-diameter, precision, achromatic objective lens. First-surface-mirror star diagonal for easy viewing. Removable eyepiece. Glare stops in tube. Main tube 38" long. Has a clamp instead of a tripod so that you can attach it to any convenient object to get a sturdier mounting than is possible with a low-cost tripod. ⅜" f.l. eyepiece gives 67X, and a mounted Barlow lens is included, giving about 100X. As lower powers are more satisfactory, accessory eyepieces and lens erecting system for terrestrial viewing are available. Included free are 272-page "Handbook of the Heavens," Star Chart, and 16-page manual.

Stock #80,061-Y.....$19.95 ppd.

WAR-SURPLUS TELESCOPE EYEPIECE

Mounted Kellner Eyepiece, Type 3, 2 achromats, f.l. 28 mm., eye relief 22 mm. An extension added, O.D. 1⅛", standard for most types of telescopes. Gov't. cost $26.50.

Stock #5223-Y.....$7.95 ppd.

EDSCORP SATELLITE TELESCOPE

OPTICS: The Satellite Scope has two important optical characteristics: A wide (51-mm.) diameter, low-reflection-coated objective lens. A six-element extremely wide-field, coated Erfle eyepiece that, in combination with the objective, gives 5.5 power with a big 12° field and over 7-mm. exit pupil.

OTHER USES FOR THE SATELLITE SCOPE

1. Makes a perfect wide-field finder. A special groove on the barrel helps in locating it in the finder mount. Fits our twin-ring finder mount, Stock No. 70,079-Y—$9.95. 2. Use the Erfle eyepiece on your regular astronomical telescope. You will need our adapter, Stock No. 30,171-Y — $3.95, which gives you an O.D. of 1¼". This eyepiece cost the government $56.00! 3. Makes a wonderful comet seeker; see complete asterisms. 4. Makes a fine rich-field telescope; see wide areas of sky with deep penetration.

Especially Made for Members of MOONWATCH
Stock #70,074-Y.....$49.50 ppd.

Now — See the Satellites

NEW, LOW-PRICE "SATELLITER" TELESCOPE

First Time — Only $9.95 ppd.

Get ready for the sky show as more satellites are vaulted into space. Our new, low-price "Satelliter" telescope may also be used to view comets and as a rich-field scope for viewing star clusters. 5 power, wide 12° field, slight distortion at outer edges because of unusual wide field. Use of high-quality war-surplus optics makes possible this bargain. Full 2" achromatic objective — large 9-mm. exit pupil for night use. Scope is 10" long, weighs less than one pound.

Stock #70,150-Y.....$9.95 ppd.

ROTATING STAR CHART

Planisphere with a rotating chart shows well over 500 stars in the heavens and their relationships to each other at any selected day and hour. Table on reverse side supplies valuable information on constellations, navigation stars, locations of the planets according to month and year, dates of meteor showers, the zodiac, and the like.

Stock #9227-Y.....$.50 ppd.

THE METZGER GLARE-REDUCTION SCREEN

The Metzger Glare-Reduction Screen is an accessory to refractors and reflectors, designed to cut planetary glare and help in observing finer planetary detail. The kraft-paper mount affords ample protection to the screen, which should be flat.

Stock #70,138-Y—for 5" O.D. tubes.....$2.95 ppd.
Stock #70,139-Y—for 7" O.D. tubes.....$3.95 ppd.

ASTRONOMICAL TELESCOPE TUBING

Stock No.	I.D.	O.D.	Lgth.	Description	Price
80,038-Y	4⅞"	5¼"	46"	Spiral-wound paper	$2.50
85,008-Y	6⅞"	7⅛"	60"		4.00
85,011-Y	2⅞"	3"	48"	Aluminum	6.00
85,012-Y	3⅞"	4"	60"		8.75
85,013-Y	4⅞"	5"	48"		9.00
85,014-Y	6⅞"	7"	60"		15.00

All tubing is shipped f.o.b. Barrington, N. J.

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Great Project for Geophysical Year!

A fascinating new field. You can build your own solar furnace for experimentation — many practical uses. It's easy, inexpensive — use your scrap wood. We furnish instruction sheet. This sun-powered furnace will generate terrific heat — 2000° to 3000°. Fuses enamel to metal. Produces many unusual fusing effects. Sets paper aflame in seconds. Use our Fresnel lens — 14¾" diameter, f.l. 14".

Stock #70,130-Y....Package of 1.....$6.00 ppd.
Stock #70,131-Y....Package of 2.....11.00 ppd.
Stock #70,132-Y....Package of 4.....20.00 ppd.

Rack & Pinion Eyepiece Mounts

For Reflectors

For Refractors

Now you can improve performance in a most important part of your telescope — the eyepiece holder. Smooth, trouble-free focusing will help you to get professional performance. Look at all these fine features: real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting; focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

Stock #50,077-Y (less diagonal holder).....$9.95 ppd.
Stock #60,035-Y (diagonal holder only).....1.00 ppd.
Stock #50,103-Y (for 2⅞" I.D. tubing).....12.95 ppd.
Stock #50,108-Y (for 3⅞" I.D. tubing).....13.95 ppd.

HUYGENS EYEPIECES

Here are some really terrific values in eyepieces! The three eyepieces listed below are manufactured by one of the world's best producers of optical components. We have searched the world's markets, including Germany and France, to find a real quality eyepiece. The image clarity, the workmanship evidenced in the metal parts, will prove the skill and experience of Goto Optical Company, Tokyo. Guaranteed terrific buys!

HUYGENS TYPE — STANDARD 1¼" DIAMETER
6-mm. (¼") Focal Length
Stock #30,063-Y.....$8.50 ppd.

12.5-mm. (½") Focal Length
Stock #30,064-Y.....$8.00 ppd.

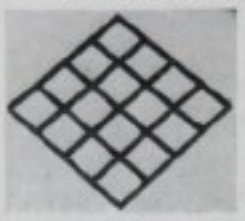
COMBINATION EYEPIECE — 10-mm. and 20-mm.
Stock #30,065-Y.....$9.00 ppd.

7X FINDER TELESCOPE—ACHROMATIC

Stock #50,080-Y Finder alone, less ring mounts...$9.95
Stock #50,075-Y Ring mounts per pair.....$3.95

RUBBER PITCH-LAP MAT

Saves Mirror Makers Time and Trouble

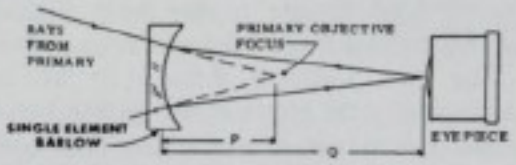


A rubber pitch-lap mat is used for forming the pitch-lap channels. Just pour the melted pitch on the tool, lay the mat on top and then press it in with your mirror to form the channels. When the pitch sets, an easy pull will remove the mat. In minutes instead of hours you are ready to polish. Eliminates time-consuming and tedious hand-cutting of the channels of the pitch lap.

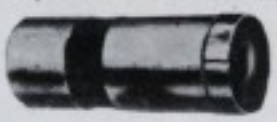
All those disappointing break outs of the pitch, common when hand-cutting the channels, are avoided. You no longer have to pour and cut two or three laps before getting a usable one. With our Rubber Pitch-Lap Mat you can use the first one you make.

Stock No.	Size	For Mirror Dia.	Price ppd.
50,171-Y	13½" x 13½"	8", 10", 12"	$2.00
60,061-Y	6" x 6"	4¼", 6"	1.00

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q!



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing with special spacer rings that enable you to vary easily the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Two pieces provided, one for regular focal length eyepieces and one for short focal length ones.

Remember, in addition to doubling and tripling your power, a Barlow lens increases your eye relief and makes using a short focal length eyepiece easier.

Don't fail to try one of these. Many people do not realize the many advantages of a Barlow and the much greater use they can get from their telescopes. Our Barlow has a focal length of −1-5/16". We have received many complimentary letters about this lens. So sure are we that you will like it that we sell it under a 30-day guarantee of satisfaction or your full purchase price returned — no questions asked. You can't lose, so order today.

Stock #30,200-Y Mounted Barlow lens.....$8.00 ppd.

OPTICAL IDEA and GADGET CONTESTS

In celebration of International Geophysical Year—

First Contest Ends April 30, 1958
Second Contest Ends Dec. 31, 1958

Our Catalog has full details on rules, prizes and entry blank — Write for Catalog "Y."

PRISM STAR DIAGONAL

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

Stock #70,077-Y.....$12.00 ppd.

SPITZ MOONSCOPE

A precision-made 32-power reflecting telescope — by makers of Spitz Jr. Planetarium. Clearly reveals the craters of the moon, shows moons of Jupiter, other wonders of the heavens. Based on same principles as world's giant telescopes. Stands 36" high on removable legs. Adjustable 3" polished and corrected mirror. Fork-type altazimuth mount rotates on full 360° circle — swings to any location in the sky. Fascinating 18-page instruction book; sturdy carrying case.

Stock #70,068-Y.....$14.95 ppd.

"MAKE-YOUR-OWN" 4¼" MIRROR KIT

The same fine mirror as used in our telescopes, polished and aluminized, lenses for eyepieces, and diagonal. No metal parts.

Stock #50,074-Y.....$16.25 ppd.

6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm. diam. objective. Weighs less than ½ pound.

Stock #50,121-Y.....$8.00 ppd.

MISCELLANEOUS ITEMS

KELLNER EYEPIECE — 2" focal length (1¼" O.D.). Mount of black anodized aluminum.
Stock #30,189-Y.....$6.00 ppd.

60° SPECTROMETER PRISM — Polished surfaces 18-mm. x 30-mm. — flat to ½ wave length.
Stock #30,143-Y.....$8.25 ppd.

BRASS TUBING

2 pieces, 3" long, slide fitting. Blackened brass. I.D. 1-3/16", O.D. 1-5/16".
Stock #40,165-Y.....$1.75 ppd.

30-day Money Back Guarantee as with all our Merchandise!

BE SURE TO GET FREE CATALOG "Y"

Fantastic variety — never before have so many lenses, prisms, optical instruments, and components been offered from one source. Positively the greatest assembly of bargains in all America. Imported! War Surplus! Hundreds of other hard-to-get optical items. Write for Free Catalog "Y."

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Pitch Polished, Beral Coated

Rectangular shape
1⅜" x 1⅞"
½ wave $1.75 each
¼ wave $4.50 each
Postpaid.

Elliptical shape
Heavy edges to minimize temperature effects.
1¼" minor axis.
½ wave $4.00 each
¼ wave $6.50 each
Postpaid.

BERAL COATINGS — same optical characteristics as aluminum — mechanically more durable — not over-coated — may be removed without harming glass surface. Prices for Beral coating telescope mirrors: 4" diam. - $2.75, 6" - $5.50, 8" - $4.50, 10" - $6.50, and 12½" - $9.75 each, f.o.b. Skokie.

LEROY M. E. CLAUSING
8038 Monticello Ave. Skokie, Ill.

TRIGARTH TURRET

and

Eyepiece Attachment with Rack and Pinion

Just turn the Trigarth Turret and easily improve the performance of your telescope. It holds three eyepieces of standard 1¼" O.D. The Trigarth Turret sells for **$15.95 postpaid.**

The Eyepiece Attachment with Rack and Pinion also takes standard 1¼" O.D. eyepieces. The rack and pinion is machined from solid aluminum castings, precisely fitted for smooth performance. The main tube is 1¾" long; sliding tube adds 2"; total movement 3⅜". Choice of gray or black crinkle finish. The Eyepiece Attachment with Rack and Pinion is priced at **$15.95 postpaid.**

MIRROR CELLS

Made of light, sturdy aluminum, each is ideal for securing the mirror to the tube. The cells are spring adjusted to absorb shocks and are cut away for ventilation.
6" — $7.00
8" — $11.50
10" — $35.00

BUILD YOUR OWN TELESCOPE
Prisms Lenses Eyepieces
Mirrors ground to your order
Aluminizing—with Quartz Coating
Satisfaction Guaranteed
Write for Free Catalog. Instructions, 10¢.

GARTH OPTICAL COMPANY
P. O. Box 991 Springfield 1, Mass.

GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

A Prime-Focus Camera for a Large Amateur Reflector — I

VISUAL OBSERVING with my 12½-inch Springfield-mounted reflector, which was described in this department in November, December, 1956, and January, 1957, has been a source of great pleasure. But like many other amateurs, after seeing the regularly observed objects many times, I wanted to make photographs of some of them.

My first attempt was with a camera mounted as shown in Fig. 1, using an Aero-Ektar lens of 3½-inch aperture and 24-inch focus. But this arrangement could not be used effectively in exposures of two or three hours duration with my Springfield mounting, for I had considerable trouble with flexure in the main instrument, which was used for guiding.

The best solution seemed to be to photograph and guide at the prime focus of the f/8 mirror, a procedure employed at many professional observatories. I decided to build a camera similar to that on the 36-inch Crossley reflector of Lick Observatory; that camera was pictured on the front cover of *Sky and Telescope* for November, 1948.

Guiding at the prime focus, close to the plateholder, eliminates two serious problems, flexure in the telescope tube and supports, and migration of the mirror; these errors cannot be compensated for by guiding if a separate camera or a guiding telescope is attached to the telescope tube. Furthermore, placing the photographic plate inside the telescope at the prime focus saves the light that would be absorbed in the extra reflection to a Newtonian focus.

When one seeks to photograph deep-sky objects, the average celestial camera that amateurs use, either of the conventional lens type or Schmidt design, suffers from two important limitations. First, the scale of the camera gives extremely small images of planetaries, globular clusters, and galaxies, so these need considerable enlargement to bring out details; graininess of the emulsion often prevents a satisfactory reproduction. Second, the faster the lens is, the greater the sky fog for any exposure time.

The 101-inch focal length of my Springfield mirror not only yields a sizable plate scale, but because it is not too fast much longer exposures can be made before the background becomes too dense. This problem is discussed by Dr. James G. Baker in his article in *Amateur Telescope Making—Book III*, pages 21-22, and deserves serious consideration before attempting to photograph faint objects.

In Fig. 2, the prime-focus camera is seen fastened onto its supports within the telescope tube, while alongside the photograph is a key drawing of the principal parts. Five control rods are in place, two over the spider vane on the lower right, two over the vane on the upper right, and one parallel to the vane on the upper left. Turning this last rod moves the guide telescope across the operator's field of view when searching for a guide star. The rod alongside the vane on the upper right is used to raise or lower the camera in its cylinder for focusing by means of the null test on a star; this automatically brings the photographic emulsion into the focal plane prior to the exposure. Both of these rods are removed before taking a picture, as they are not aligned with the spider vanes and would cause extra diffraction effects.

The remaining rod over the vane on the upper right moves the plateholder with attached guide telescope in the operator's line of sight. It may be used for guiding in right ascension, and is essential for circumpolar exposures. Turning the top rod of the two that are over the spider vane on the lower right moves the plateholder and guide telescope in declination. The rod beneath this one opens and closes a hinged shutter.

The bottom hole in the right side of the tube is for setting a high-speed shutter that can be placed in the camera for short exposures on objects such as the moon. The upper hole provides access for the operator's left hand to slide the guide

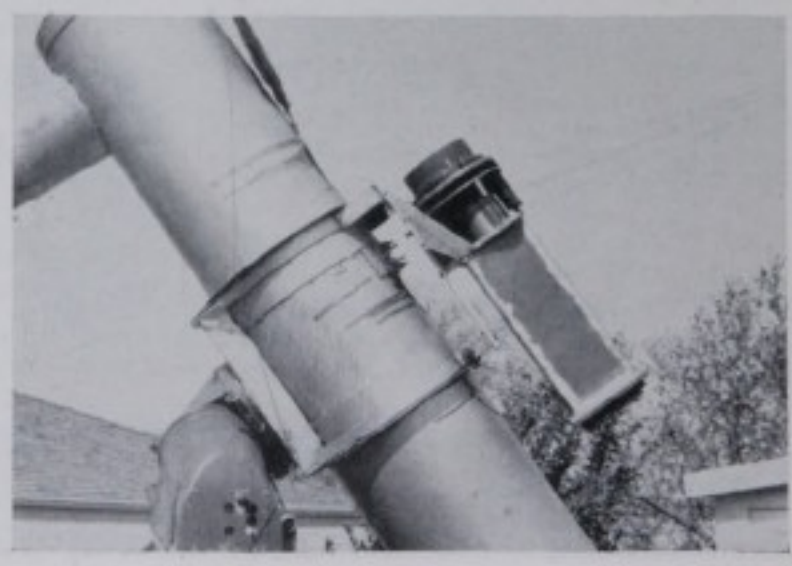
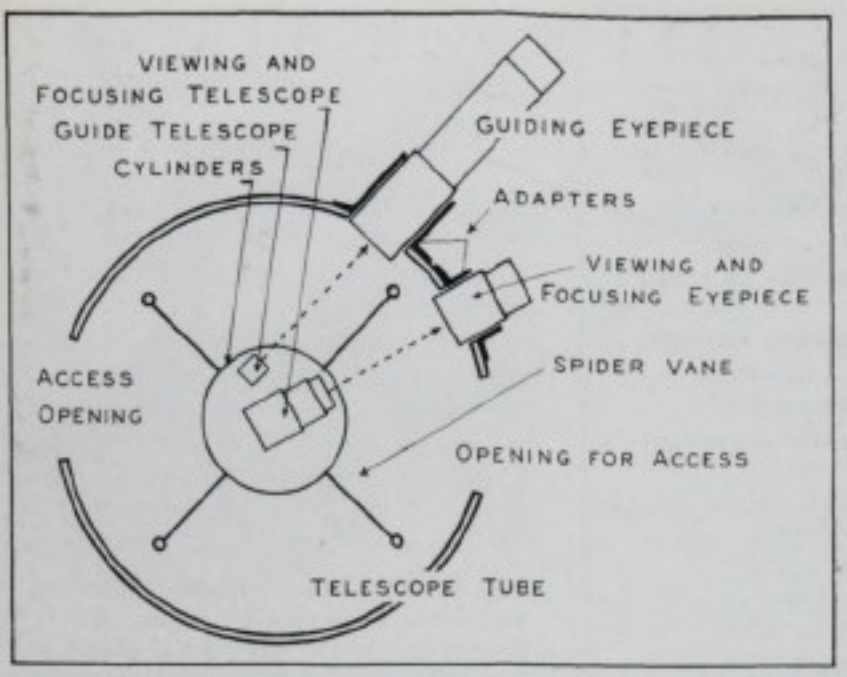


Fig. 1. Clarence P. Custer mounted a 3½-inch aerial camera lens and plateholder combination on the side of his 12½-inch Springfield telescope. The main instrument was used for guiding, but the arrangement was not satisfactory for pictures of long exposure.



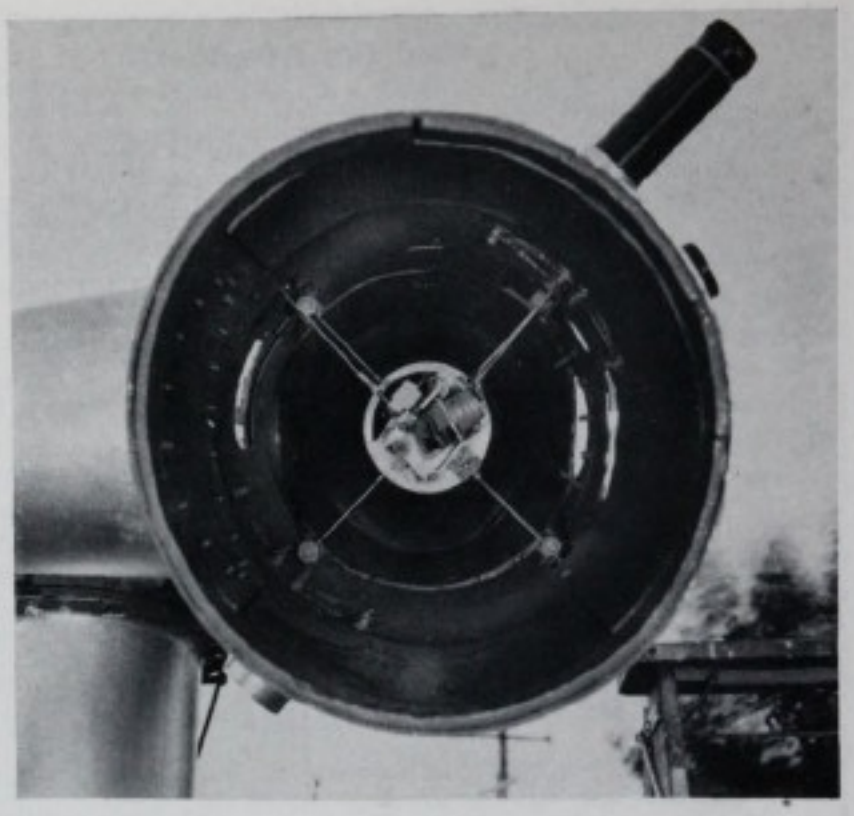


Fig. 2. The diagram above identifies the parts of the prime-focus camera seen at the right, where the view is directly into the main tube of the Custer reflector.

telescope manually in the line of sight for finding a guide star, to insert the plate-holder, or to make other adjustments. The opposite hole, on the left side of the tube, is similarly used for photography from that side of the telescope.

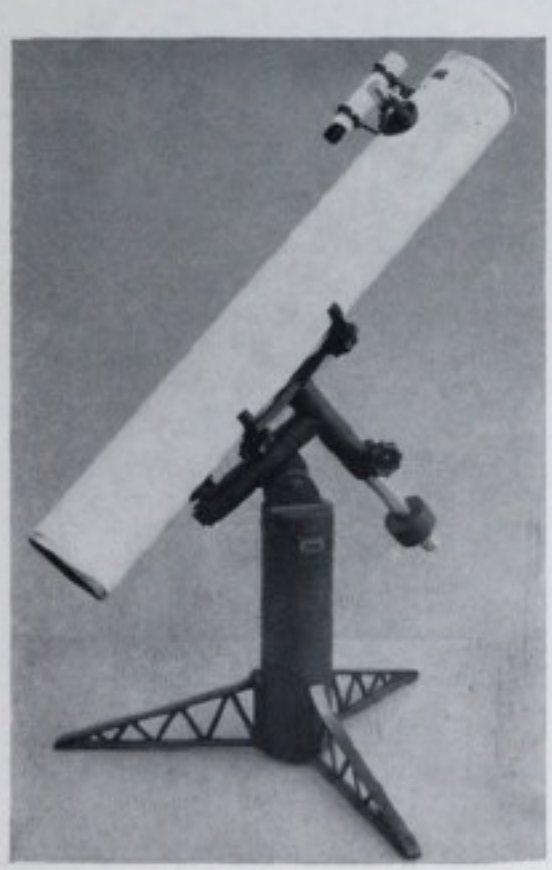
On the outside of the main tube (at the upper right in Fig. 2) are the long tube of the guiding eyepiece and the short one of the field-viewing and focusing eyepiece, its tip just visible in the picture.

Numerous hidden details of the assembled instrument are shown in some further pictures. Fig. 3 is a view of the two concentric cylinders that carry the various parts of the camera and the four supporting vanes. The outer cylinder is 5" in diameter, and cuts off about 16 per cent of the incoming light. The inner brass sleeve fits snugly within the outer one, preventing shake during focusing, yet not so tightly that temperature changes could cause sticking.

Along the spider vane in the lower left is the control rod that is used for turning a set of beveled gears to raise or lower the inner cylinder. The gear mechanism, which in Fig. 3 is hidden under the projecting support on the inner wall, provides a 2-to-1 reduction. A small threaded post, also concealed, extends downward from the gears and is large enough in diameter to prevent binding or laboring under load.

The spring of the hinged shutter con-

ASTROLA Reflecting Telescopes



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STANDARD MODEL "A",	6-inch	**$295.00**
STANDARD MODEL "B",	8-inch	**$375.00**
STANDARD MODEL "C",	10-inch	**$475.00**

These instruments are fully portable—as they can be assembled or taken down in three minutes. Each comes with three of the finest oculars. The equatorial head and stand are of cast aluminum. The fiberglass tube is made by W. R. Parks. Optics are corrected to ⅛ wave or better and are quartz coated. ASTROLAS will resolve double stars to the Dawes limit. Clock drives, rotating tubes, setting circles furnished at additional cost.

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Here is a combination of a Barlow and a particular ocular which gives outstanding results. It consists of our new Barlow and our 16.3-mm. (2/3" focal length) Erfle eyepiece. While the Barlow was not specifically designed to work with this eyepiece, it does so to an astonishing degree. All images are sharp and hard to the very edge of the field.

The Barlow gives magnification up to slightly over three times that of the ocular alone. It is achromatic, coated, and mounted to the U. S. standard size of 1.250 inches.

The modified Erfle eyepiece has a field of 75 degrees with excellent eye relief. The combination gives the equivalent focal length of slightly under 6 mm. Many users state it is far superior to any shorter focal length ocular of equivalent magnification.

The Barlow sells for $16.00 postpaid, and the Erfle for $14.75 postpaid. Both are guaranteed to perform as stated above or money refunded.

ORTHOSCOPIC OCULARS—All hard coated, standard 1¼-inch outside diameter.

28-mm.	$15.00	10.5-mm.	$16.25	4-mm.	$17.25
16.3-mm. (Erfle)	$14.75	7-mm.	$17.25	Barlow 3x	$16.00

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Every instrument, with its ¼-wave, aluminized mirror, is individually tested before being packed for shipment. We suggest that before buying you inquire at almost any local astronomy society about the efficiency of Skyscope. *100% American-made.*

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125-power and 35-power extra eyepieces	$5.15 each
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Fig. 3. The inner cylinder slides up and down to focus the camera, that is, to put it into the exact focal plane of the telescope mirror at the time the picture is taken.

trol is seen in Fig. 4 (upper part), on the metal rod fastened to the left side of the camera base plate. The shutter-control rod extending to the left in the lower part of Fig. 4 is the same as one of those in Fig. 2 (bottom rod over vane in lower right). The circular segment opening on the right side of the base plate is the area in which the observer looks for a suitable guide star.

On top of the base plate are mounted the various carriers, plates that slide

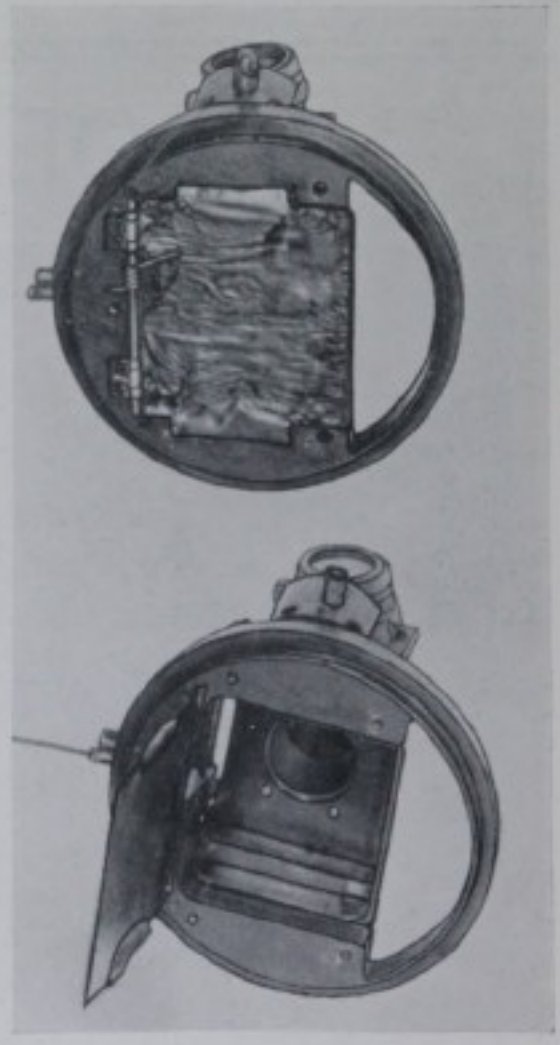

Fig. 4. The supporting plate for the camera parts, seen from the side toward the telescope mirror. In the upper part the shutter is closed, and in the lower part it is open.

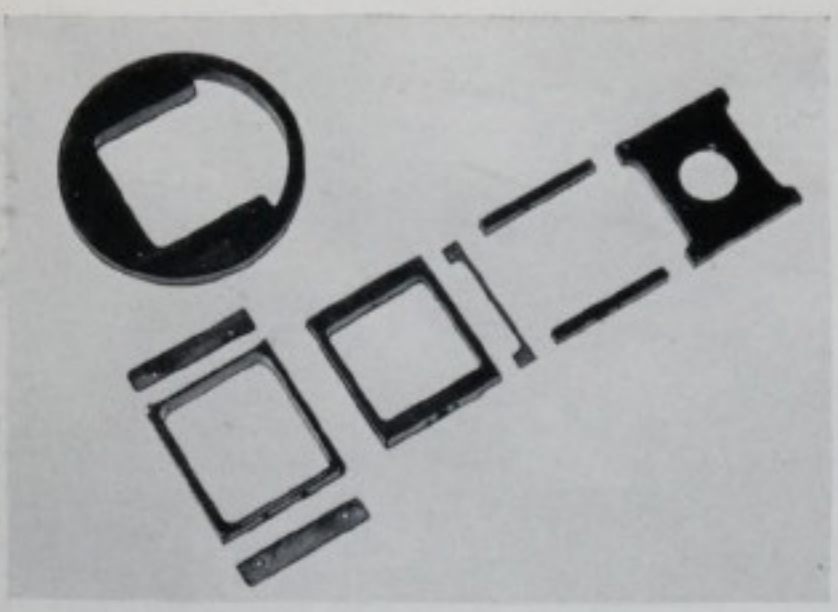

Fig. 5. The base plate, in the upper left, and its carrier parts. A cross-section of the assembly is at the right.

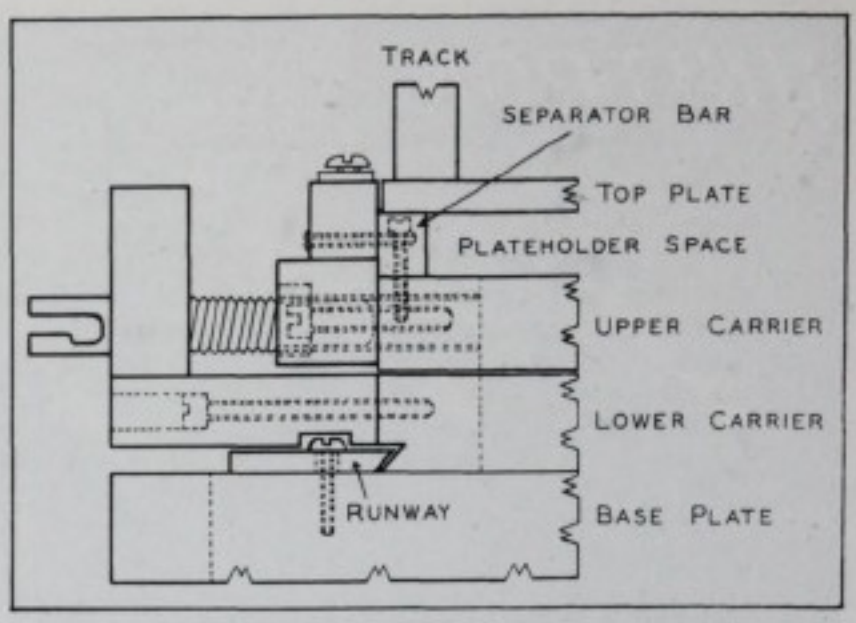

Fig. 6. Illustrating the arrangement of the carrier parts and the space for the plateholder.

smoothly in carefully assembled and machined grooves. These carriers provide the motions for guiding during the exposure. The parts that make up the heart of this camera are shown in Fig. 5. At the upper left is the base plate which fastens to the inner cylinder of the camera body, with its special cutout areas for the camera and guide telescope.

The first rectangular frame is the lower carrier, and above and below it are its runways. This carrier is dovetailed on the lower outside to slide on these runways and on the inside top to allow the upper carrier, seen just to the right, to slide upon it. This second plate is dovetailed on its left, and with the addition of the dovetailed steel gib on the right side to provide take-up adjustment, slides on the inside dovetail of the lower carrier.

To the right of the steel gib are bars that fasten to the top of the upper carrier to separate it by a distance equal to the thickness of the plateholder from the top plate, the last member of the group. This section carries the viewing and focusing telescope as well as the track for the guide telescope. More details of the carriers and their relationship are depicted in Fig. 6.

The optical field-viewing and focusing device and the system for guiding on a star will be described next month.

CLARENCE P. CUSTER, M.D.
155 E. Sonoma Ave.
Stockton, Calif.

CORRECTION

In the December issue of *Sky and Telescope*, page 97, third column, change the second last line to read: "comes 20.38, and the focal length 224.2"."

AN IMPORTANT ANNOUNCEMENT . . . .

To better serve the amateur astronomer and telescope maker, BRANDON OCULARS and BRANDON OBJECTIVES are now being sold at the **Adler Planetarium** in Chicago, Illinois. The planetarium is a nonprofit organization for spreading the knowledge of astronomy in America through exhibits and demonstrations, and assisting in the design and construction of amateur telescopes.

Our oculars and objectives can be obtained immediately by mail, or bought directly from the book counter at the

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1. Four-element design gives a flat, beautifully corrected field of 50°, covering more than 160% of the area of the conventional Ramsden for the same power.
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Brandon Instruments

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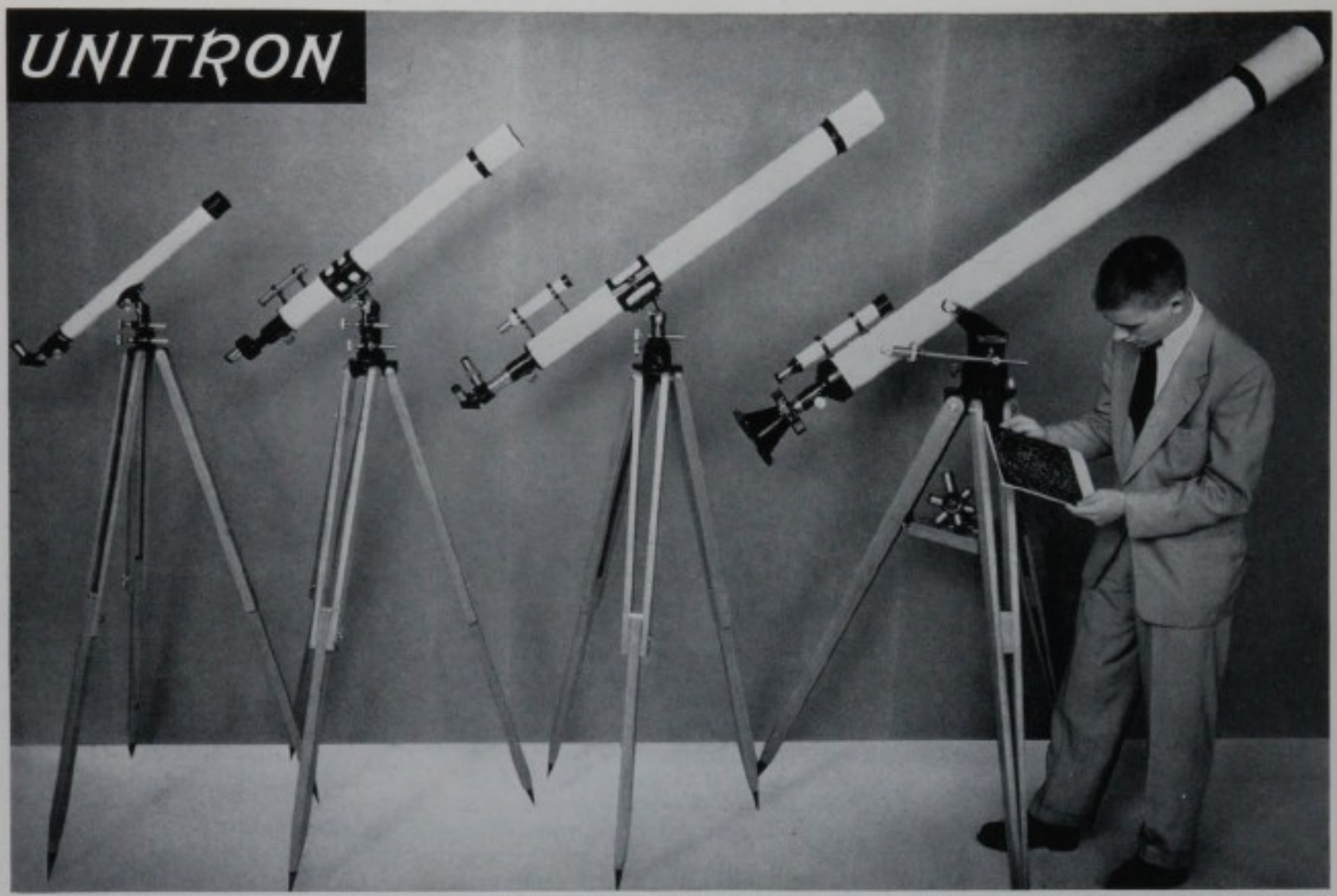

UNITRON Altazimuth Refractors: left to right, 1.6" (with star diagonal), 2.4" (with erecting prism system), 3" (with DUETRON double eyepiece), and 4" (with astro-camera and with UNIHEX on the shelf).

UNITRON Equatorial Refractors: left to right, 2.4" (with astro-camera), 3" Photo-Equatorial (with sun screen), and 4".

Start the New Year with a UNITRON Refractor

MANY Models To Choose From!

1.6" **ALTAZIMUTH** (**$7.50 Down**) **$75**
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eyepieces for 250x, 214x, 167x, 120x, 83x, 60x

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4" **EQUATORIAL** with clock drive **$985**
(**$98.50 Down**), new Model 160V

4" **EQUATORIAL** with clock drive and **$1075**
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astro-camera (**$117.50 Down**), with eyepieces
for 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

4" **PHOTO-EQUATORIAL** with clock drive, pier, **$1280**
astro-camera (**$128.00 Down**), eyepieces for 375x,
300x, 250x, 214x, 167x, 120x, 83x, 60x, 38x, 25x

Higher- and lower-power eyepieces available for all models. Prices include basic accessories, tripod and mounting, fitted wooden cabinets, and operating instructions. Additional accessories available to add further to your observing pleasure.

The old year of 1957 closed with a bang . . . the sound of the rockets that launched the artificial satellites. Events in 1958 promise to be even more exciting as the world starts to adapt to the new "space age." There is a keener interest than ever in exploring with a telescope our neighbors in the solar system as well as the more distant regions of outer space. To make the most of your observations this year, and for years to come, choose the telescope of proven optical and mechanical performance . . . . . choose a UNITRON.

- LENSES are FULLY CORRECTED for spherical and chromatic aberration and are COATED for maximum brilliance and clarity of image. Optics especially designed for astronomical observation. AIR-SPACED OBJECTIVES.
- REFRACTOR type of design duplicates the performance of larger telescopes of other types. No mirrored surfaces to become oxidized. Superior definition to the very edge of the field.
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- FINEST MATERIALS throughout. DURALUMINUM TUBE. Moving parts of BRASS carefully machined to close tolerances, and finished in CHROMIUM. No war-surplus components used.
- MODERN DESIGN based on time-tested engineering principles. HANDSOME APPEARANCE to which no illustration can do justice.
- EQUATORIAL MODELS have slow-motion controls for **both** declination and right ascension as well as rapid-motion controls. Sturdy TRIPOD.
- ALTAZIMUTH MODELS have slow-motion controls for **both** altitude and azimuth as well as clamps for both co-ordinates. Sturdy TRIPOD.
- VIEW FINDER with crosshair eyepiece.
- RACK-AND-PINION FOCUSING.
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Send check or money order in full or use our Easy Payment Plan, as described below. Shipments made express collect. Send 20% deposit for C.O.D. shipment. UNITRON instruments are fully guaranteed for quality, workmanship, and performance, and must meet with your approval or your money back.

Use Our EASY PAYMENT PLAN

UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor when you do not want to disturb your savings or when you haven't the total cost of the telescope immediately available. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is canceled.

There is no "red tape" when you order — you merely fill in the UNITRON Easy Payment Order Form, return it together with the required down payment, and the model of your choice is shipped to you at once.

Do not hesitate to use this plan merely because you have never before purchased anything on time payments. The procedure is practically painless and is an ideal means of enjoying the use of your UNITRON while paying for it.

See the back cover.

Telescope Accessories by UNITRON

UNITRON ACCESSORIES include objective lenses, eyepieces, rack-and-pinion focusing mechanisms, sun projecting screens, guide telescopes, the UNICLAMP camera brackets, and many other components in addition to those listed on this page. All are described, illustrated, and priced in the new UNITRON Catalog. Since each component is used as standard equipment in UNITRON Refractors themselves, you are assured of obtaining the finest quality.

ASTRO-CAMERA 220: Complete with air-operated curtain shutter, giving speeds of 1/10 to 1/90 second, bulb and time, shutter release, ground-glass back, 3 double plateholders for 3¼" x 4¼" plates or cut film, a 30-mm. f.l. eyepiece, extension tubes and clamps, and a fitted wooden cabinet. Model A is designed to fit the UNITRON rack and pinion and is for UNITRONS only. Model B fits 1¼" eyepiece holders. A or B:

Only $69.50 postpaid

DUETRON Double Eyepiece: With DUETRON, two observers may use the telescope simultaneously and with equal comfort. The eyepieces used need not necessarily be of the same magnification. DUETRON is a real boon for father-and-son observing teams. With DUETRON, more observers may be accommodated at star parties, and the advanced members may provide valuable instruction to the beginners. The tube of DUETRON Model A is interchangeable with the customary UNITRON drawtube and may be used with all models with the exception of the 1.6" Refractor. DUETRON Model B fits 1¼" eyepiece holders. Complete with special clamping device and cabinet. A or B:

Only $23.50 postpaid

1. **VIEW FINDER** (As shown on UNITRON 2.4" Equatorial): 23-mm. (.93") achromatic objective, 6x eyepiece with crosshairs. Chromed brass tube. Mounting brackets with centering screws.

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2. **VIEW FINDER** (As shown on UNITRON 3" Altazimuth): 30-mm. (1.2") coated achromatic objective and 8x eyepiece with crosshairs. Other details as in View Finder 3.

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3. **VIEW FINDER** (As shown on UNITRON 4" Refractors): 42-mm. (1.6") coated achromatic air-spaced objective. 10x eyepiece with crosshairs. Duraluminum tube finished in white enamel. Dewcap. Furnished with mounting brackets with centering screws for collimation. This finder also makes an excellent hand telescope for spectacular wide-field views of the sky.

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UNIHEX ROTARY EYEPIECE SELECTOR: The old-fashioned method of fumbling with eyepieces in the dark has been outmoded by UNIHEX, UNITRON's new Rotary Eyepiece Selector. With UNIHEX, you always have 6 magnifications ready at your fingertips. To change power, merely rotate a new eyepiece into position while the object stays centered and in focus in the field of view. Model A is designed to fit the UNITRON rack and pinion and is for UNITRONS only. Model B fits 1¼" eyepiece holders. Complete with special clamping device and cabinet. A or B:

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This valuable 38-page book is yours for the asking!

With artificial satellites already launched and space travel almost a reality, astronomy has become today's fastest growing hobby. UNITRON's handbook contains full-page illustrated articles on astronomy, observing, telescopes and accessories. Of interest to beginner and advanced amateurs alike.

Contents include —

- Observing the sun, moon, planets and wonders of the sky
- Constellation map
- Hints for observers
- Glossary of telescope terms
- How to choose a telescope
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Please rush to me, free of charge, UNITRON's new Observer's Guide and Telescope Catalog.

Name .....
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MINIMA OF ALGOL

January 1, 15:14; 4, 12:03; 7, 8:53; 10, 5:42; 13, 2:31; 15, 23:20; 18, 20:10; 21, 16:59; 24, 13:48; 27, 10:37; 30, 7:27. February 2, 4:16; 5, 1:05; 7, 21:55; 10, 18:44; 13, 15:33.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

HELPFUL HINTS TO OBSERVERS!

The free literature offered in the Frank Goodwin ad below includes the following subjects: telescope observational techniques and methods; cutting down sunlight externally in viewing the sun; cleaning mirrors; sealing objectives against interelement air-space dewing; how to approximate off-axis performance with your reflector by a simple black-paper mask on mirror, occulting diffraction of diagonal and struts. (Also how the Goodwin Resolving Power lens is positively guaranteed to make any good telescope perform like a larger one, for reasons stated in the ad below.)

FRANK GOODWIN
345 Belden Ave., Chicago 14, Ill.

NEW THRILLS FROM YOUR TELESCOPE!

Sharper images, wider field, more light at higher powers! A startling statement positively proven in 16-page telescopic educational matter, plus many helpful hints, sent free on receipt of self-addressed long envelope bearing 9c return postage.

First, the Goodwin Resolving Power lens placed in front of eyepiece gives three times the magnification on each by increasing the effective primary focal length up to three times, yet extends eyepiece out no more than two inches from normal. This alone sharpens definition.

Next, by achieving your highest powers on more comfortable low-power eyepieces, you lessen image deteriorations due to short-focus acute bending of the convergent beam, since all usual eyepieces are f/1 or less. Again sharper images from this highest precision lens.

Third, you get greater illumination and wider field by relieving tiny aperture restrictions of higher-power eyepieces.

The Resolving Power lens is achromatic, coated, gives flat field sharp to the edge. Here is astonishment! Price $23.50 in 4" long adapter tube fitting standard 1¼" eyepiece holders ONLY. (Also adaptable to Unitrons; state if Unitron.) Money back if not positively thrilled after two weeks trial! Used and praised by legions!

No COD's—Colleges and Observatories may send purchase order.

FRANK GOODWIN
345 Belden Ave., Chicago 14, Ill.

CELESTIAL CALENDAR

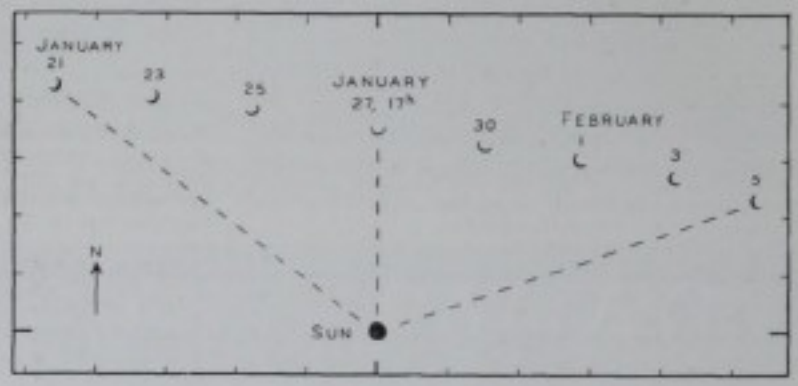
Universal time is used unless otherwise noted.

VENUS' INFERIOR CONJUNCTION

Near the end of January, the planet Venus will reach inferior conjunction, but it will pass 7° 13′ of declination north of the sun. This planet will for a time appear as a very narrow crescent, visible to observers in midnorthern latitudes both in the evening sky after sunset and in the morning sky before sunrise. Venus will still be bright, of apparent magnitude −3, but will be difficult to locate in the bright twilight, and binoculars may help find it.

Conjunction in longitude occurs on January 28th at 20^h Universal time. Conjunction in right ascension – the moment when Venus is directly north of the sun – will occur on the previous day at about 16:45. It is this conjunction that is plotted in the accompanying chart, which shows the motion of Venus relative to the sun in the sky for a two-week period.

Many observers will be able to find the planet in the middle of the day, but care should be taken to avoid eye damage when scanning the sky so near the sun. A good telescope, accurately focused, will be needed to show the thin crescent by day; a pure sky is necessary. At the beginning and end positions on the diagram, Venus will be about 2.7-per-cent illuminated, but on January 27th less than 1/100 of its surface will be seen. During the interval covered by this chart, the planet's telescopic disk will be about 1′ in diameter.



The relative positions of Venus and the sun around the time of that planet's inferior conjunction. The horizontal scale is marked with respect to the sun in 10-minute intervals of right ascension, and the vertical scale indicates two-degree intervals of declination.

MOON PHASES AND DISTANCE

Full moon	January	5, 20:09
Last quarter	January	12, 14:01
New moon	January	19, 22:08
First quarter	January	28, 2:16
Full moon	February	4, 8:05

	January	Distance	Diameter
Perigee	9, 0^h	227,600 mi.	32′ 37″
Apogee	25, 0^h	251,800 mi.	29′ 29″
	February		
Perigee	5, 23^h	224,200 mi.	33′ 07″

OCCULTATION PREDICTIONS

January 2-3 **Epsilon Tauri** 3.6, 4:26.2 +19-05.3, 13. Im: **C** 2:45.7 ... ... 21; **F** 1:47.0 −1.0 +3.2 36.

January 12-13 **Alpha Virginis** 1.2, 13:23.0 −10-56.6, 22. Im: **E** 16:38.8 −0.6 −1.4 99; **F** 16:47.6 −0.8 −1.7 117; **H** 16:12.1 −1.6 −1.4 111; **I** 15:52.6 −1.5 −0.8 90. Em: **F** 17:49.4 −0.3 −1.1 273; **H** 17:26.6 −1.1 −1.5 288; **I** 17:00.1 −1.0 −1.8 310.

January 15-16 **Nu Scorpii** m 4.3, 16:09.6 −19-21.2, 25. Im: **I** 15:06.8 ... ... 40.

The symbol "m" following the star name indicates that the prediction is an average for the components of a double or multiple star. Nu Scorpii is quadruple. It consists of a 4th-magnitude star with a 6.4 companion only 1.0 second of arc away, and 41 seconds distant is a 2.1-second pair, magnitudes 6.8 and 7.8. Hence, with a telescope of sufficient resolution, Nu Scorpii may be seen on January 15-16 to disappear behind the moon in four stages.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo**−**LoS**), and multiply **b** by the difference in latitude (**L**−**LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

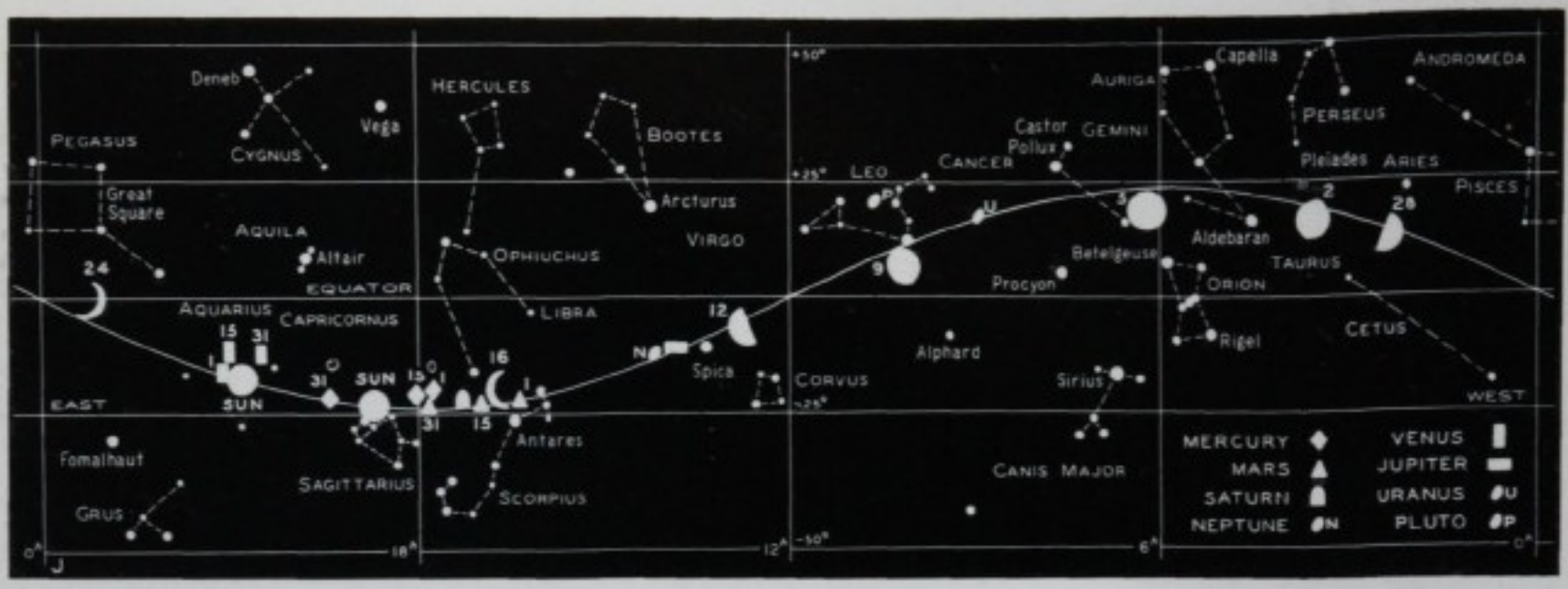
A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
		I +123°.1,	+49°.5		

VARIABLE STAR MAXIMA

January 2, S Sculptoris, 001032, 6.8; 18, RT Cygni, 194048, 7.4; 18, RS Librae, 151822, 7.7; 23, R Virginis, 123307, 6.9; 25, S Pavonis, 194659, 7.3; 26, T Herculis, 180531, 8.0; 26, L_2 Puppis, 071044, 3.4; 28, R Aquilae, 190108, 6.3.

February 11, R Phoenicis, 235150, 7.8.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0h Universal time on the respective dates.

During most of January, for observers in midnorthern latitudes all the planets except Venus will be in the sky at sunrise, and in the last week Venus, too, will rise ahead of the sun.

Mercury arrives at greatest western elongation on January 16th, 23° 53′ from the sun. It is of magnitude 0.0 on this date, rising about 1½ hours before the sun. The planet should be visible in the morning sky about a week before, and two weeks after, elongation.

Venus is magnitude −4.3 on the 1st, and sets about 2¾ hours after the sun. It is moving rapidly toward the sun in the sky, inferior conjunction occurring on the 28th (see page 154). It may be possible to follow Venus with the unaided eye to within three days of conjunction, when it will set about half an hour after the sun. During the month the planet's disk increases in diameter from 46″ to 62″, and can be seen as a small crescent in field glasses. On the evening of the 20th Venus will have a close conjunction with the moon.

Earth reaches perihelion on January 3rd at 14h UT. It is then only 91.4 million miles from the sun.

Mars is in the morning sky, a reddish +1.7-magnitude object rising in midmonth about 2½ hours before sunrise. It is in southern Ophiuchus most of the month. On the 4th Mars will pass some 4½° north of Antares; comparison of the planet with "the rival of Mars" should interest many amateurs. There will be a conjunction with Saturn on the 23rd, Mars passing 1½° south of it.

Jupiter reaches western quadrature on January 21st, when it will rise a little after midnight. A conjunction with the moon occurs early in the morning of the 13th, with Jupiter 2° north. On the 15th the giant planet is of magnitude −1.5, and telescopically its disk will have an equatorial diameter of 36″.1, a polar diameter of 33″.7.

Saturn is a +0.8-magnitude object in southern Ophiuchus, rising in midmonth about 2½ hours before the sun.

Uranus can be seen with field glasses as a 6th-magnitude object in Cancer. It is in opposition to the sun on the 30th, when it rises at sunset and stays visible all night. Its apparent right ascension and declination are 8h 53m.8, +18° 10′ on January 1st, and 8h 48m.8, +18° 30′ on the 31st.

Neptune is in eastern Virgo and can be seen with a small telescope. It reaches western quadrature on January 25th, rising about midnight, local time. Its apparent co-ordinates in midmonth are 14h 11m.9, −11° 26′.

W. H. G.

JANUARY METEORS

Observations of the Quadrantid meteor shower, which occurs on January 3rd, will be severely hampered this year by the nearly full moon. Under more favorable conditions, a single observer may count as many as 35 meteors an hour. The radiant point is in northern Bootes, at right ascension 15h 20m, declination +50°.

W. H. G.

AIRPLANE SIGHTINGS OF COMETS

On page 569 of the October issue, it is stated that pilot Peter Cherbak's sighting of Comet 1957d was perhaps the first comet discovery ever made from an airplane.

Comet 1948l was similarly detected by a pilot flying from the Fiji Islands to Sydney, Australia, on November 8, 1948. While this bright comet had been observed a week earlier by a British eclipse expedition in Kenya, Africa, the first news of it here in Sydney was the press report of its finding by the airline pilot, whose name has not been preserved.

RICHARD REDMOND
Sydney, Australia

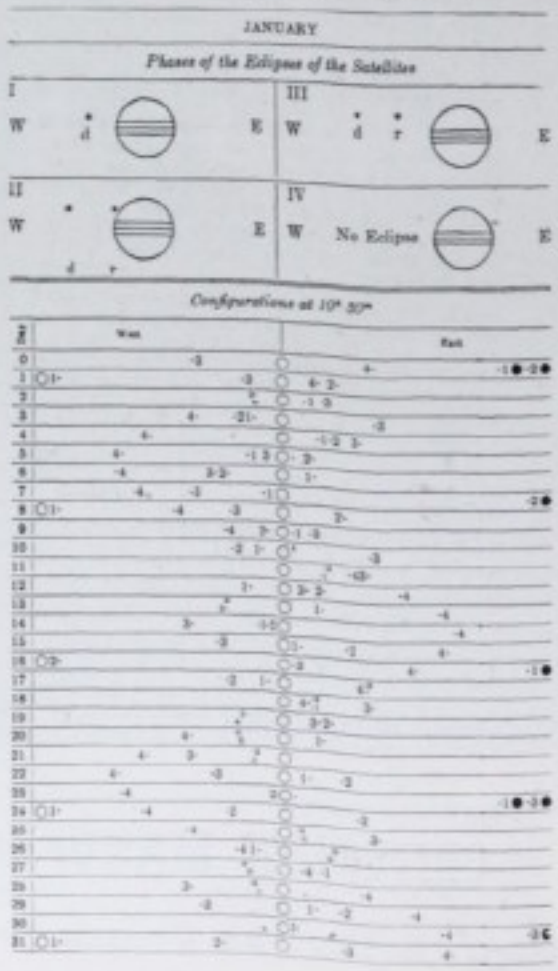
ED. NOTE: For many years, the material for this page has been prepared by Edward G. Oravec, of Tuckahoe, New York, a well-known amateur astronomer, but the pressure of other activities prevents him from continuing this valuable contribution to *Sky and Telescope*.

The copy is now being prepared by another member of the Amateur Astronomers Association in New York City, William H. Glenn, who has written many items for *Eyepiece*, the bulletin of the observing group of that society.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from the *American Ephemeris and Nautical Almanac*.



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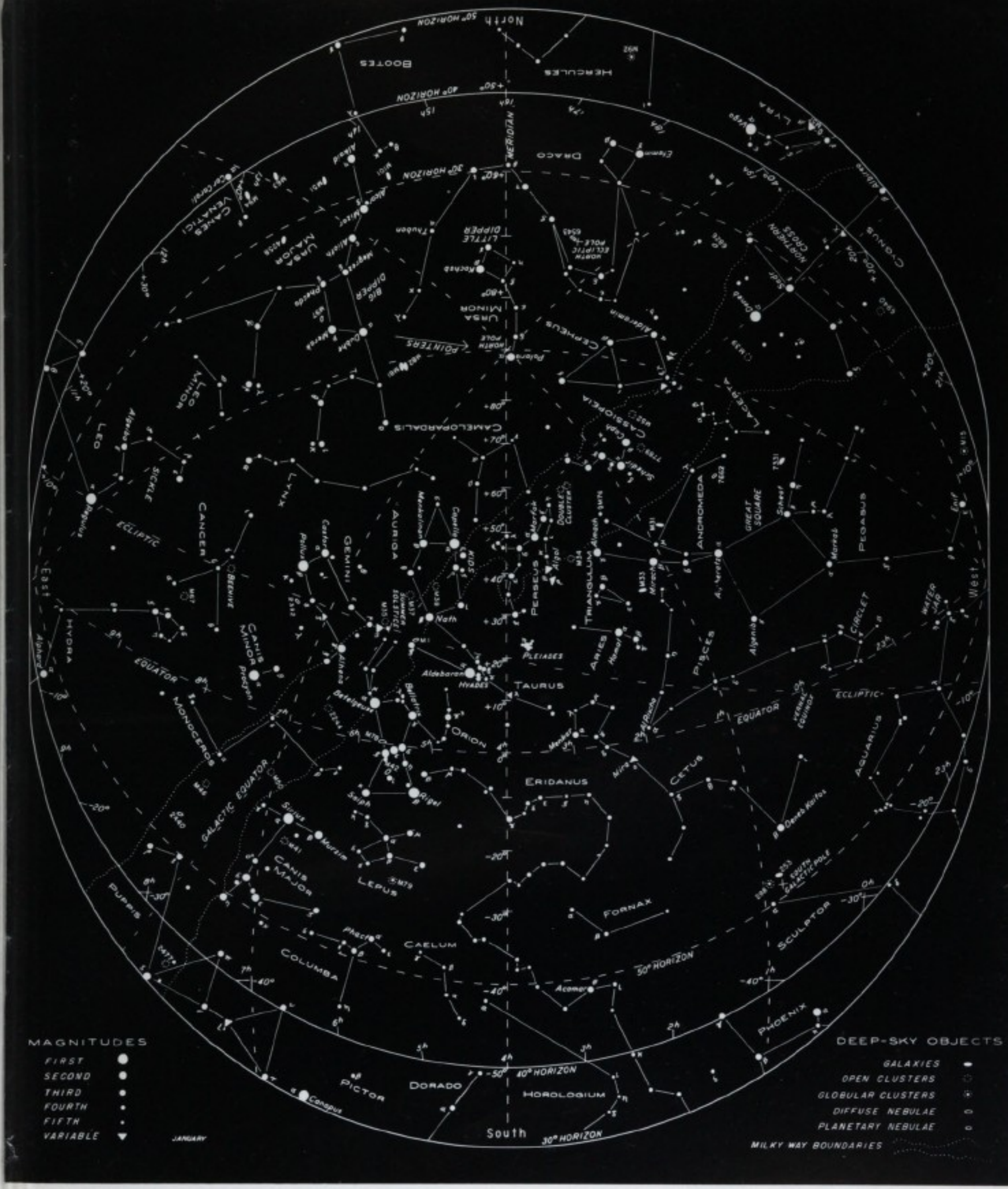
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URSA MINOR
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Sirius
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Betelgeux
Aldebaran
Capella
Menkalinan
Castor
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Alhena
Wasat
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Adhara
Phact
Naos
Suhail
Canopus
Achernar
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Kaus Borealis
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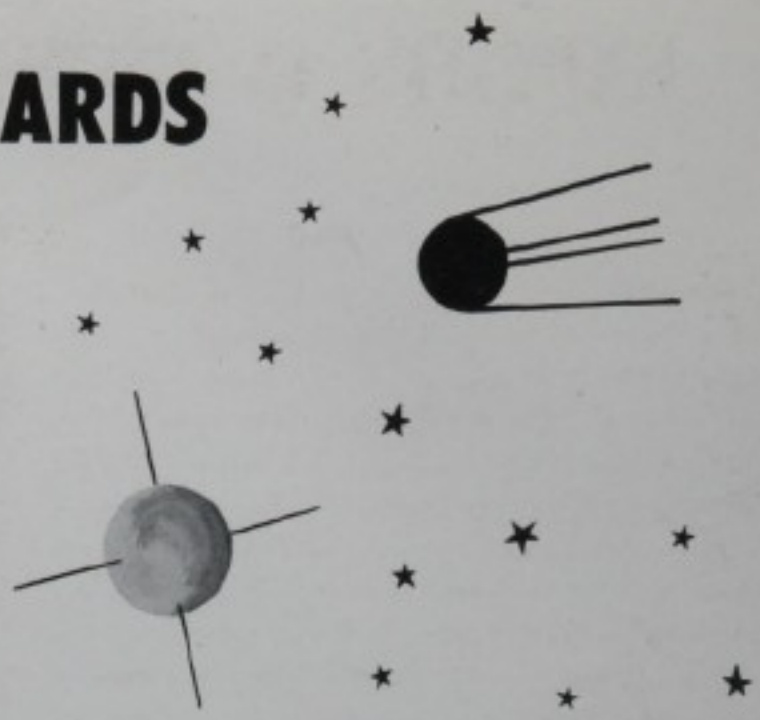

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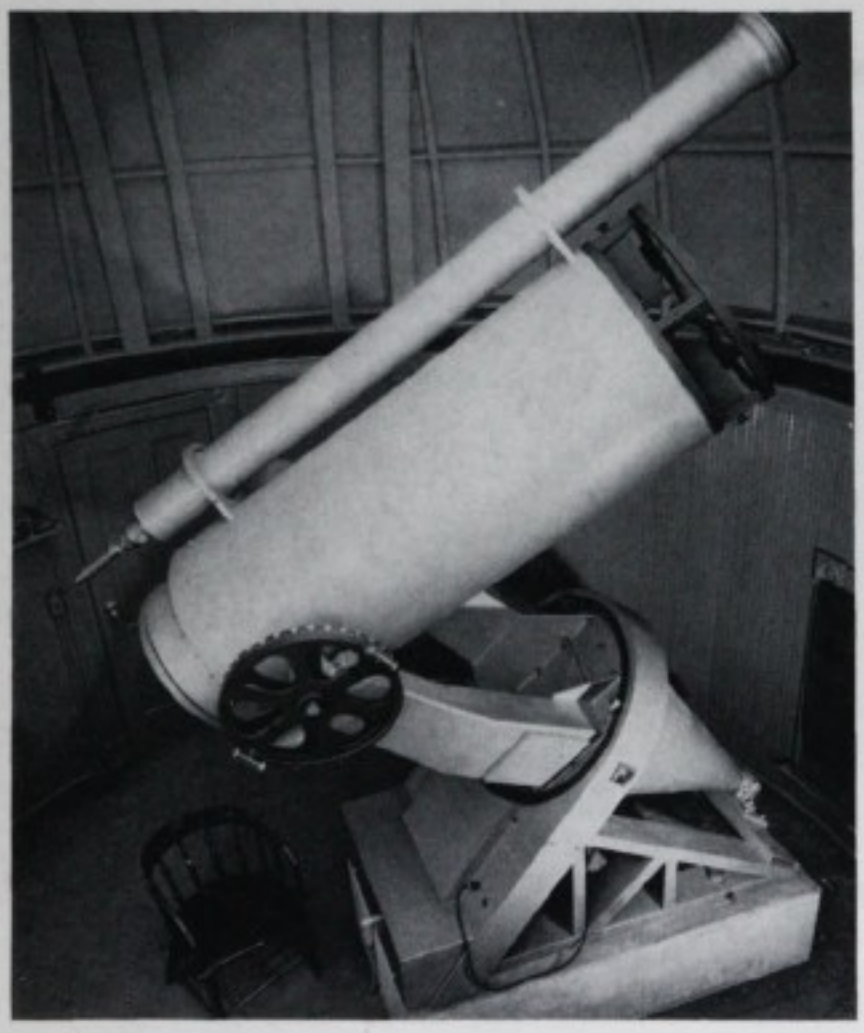

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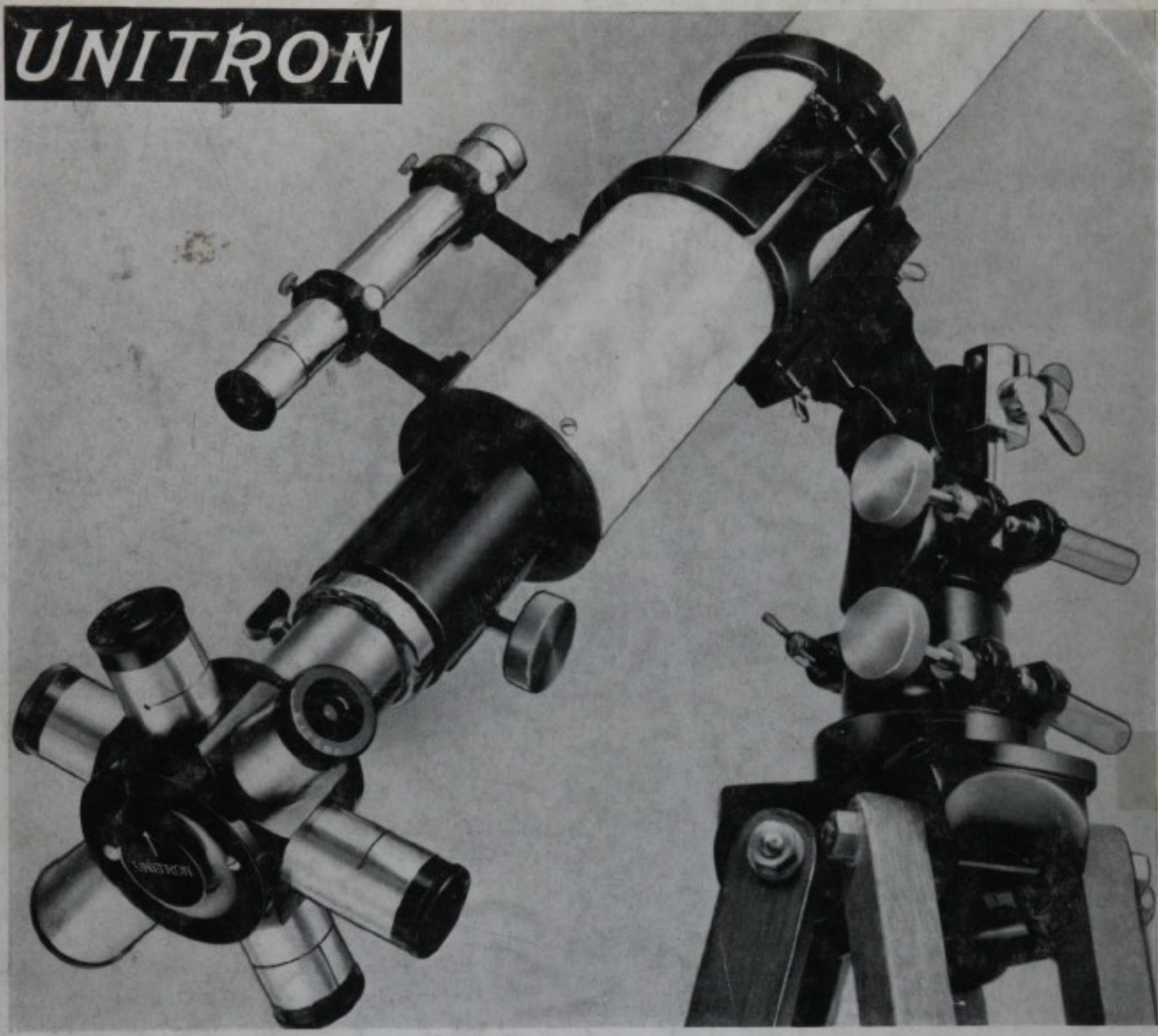

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See pages 152 and 153.

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